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APRIL, 1961

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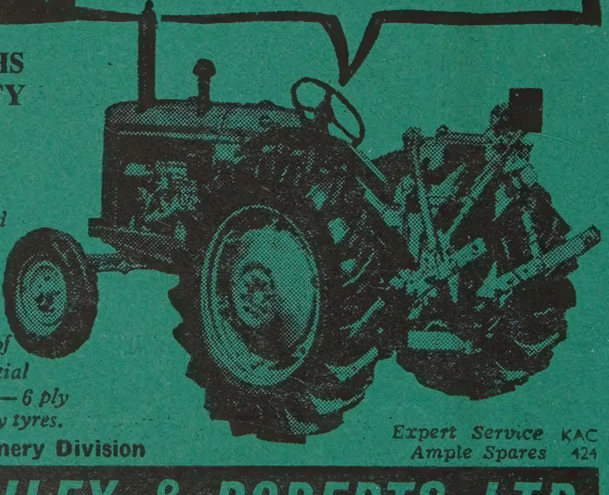

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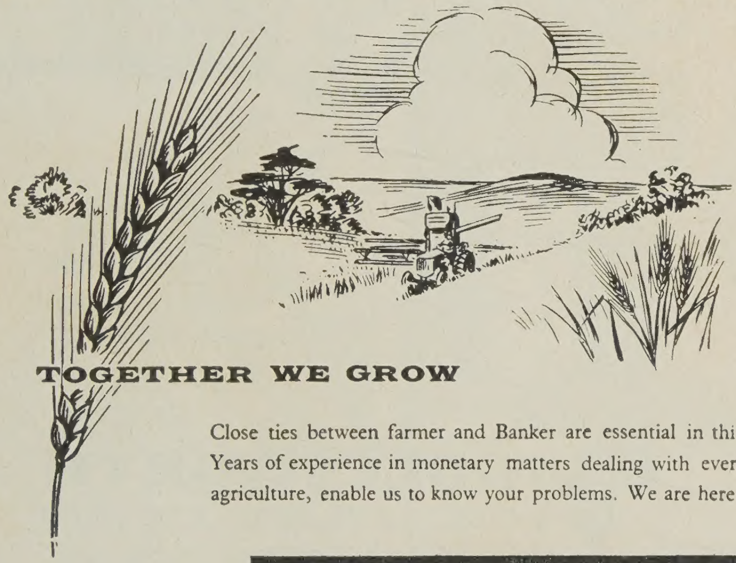

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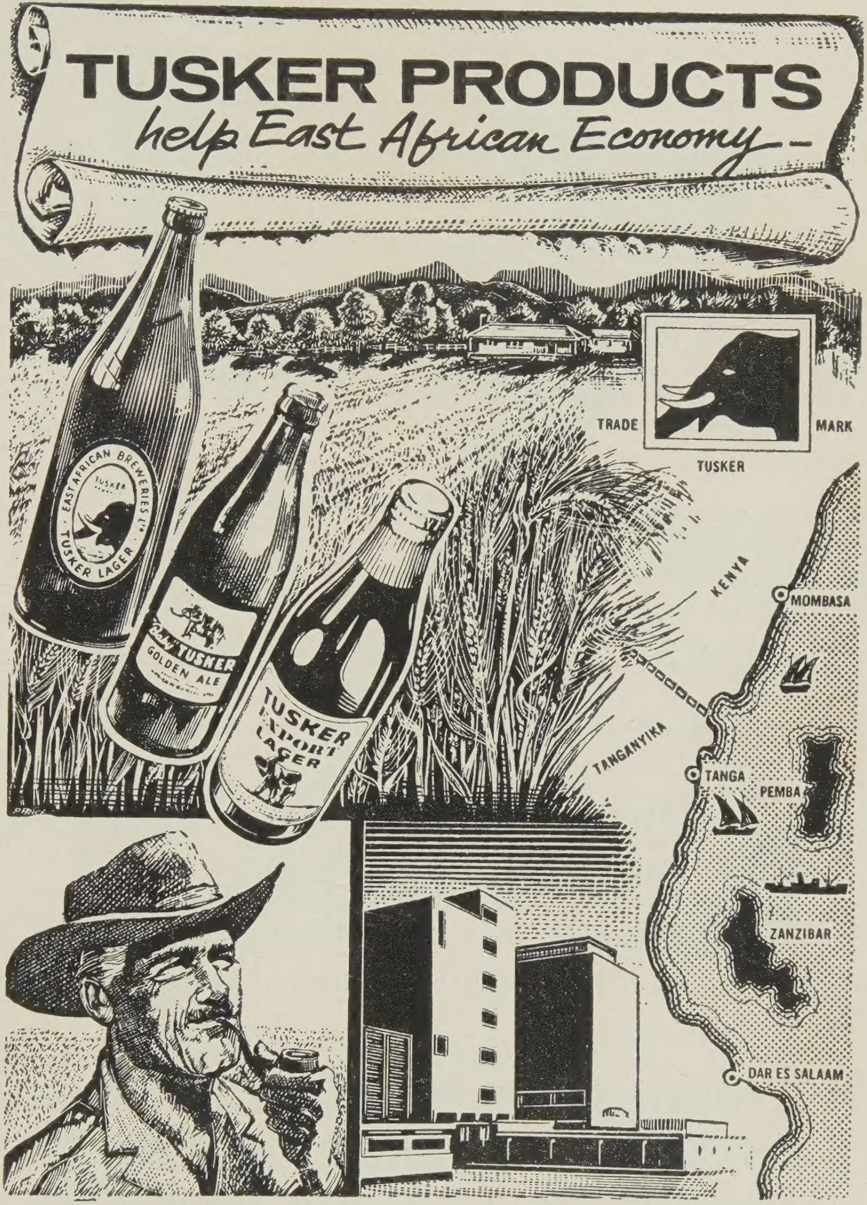

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EAST AFRICAN AGRICULTURAL AND FORESTRY JOURNAL

FURTHER OBSERVATIONS CONCERNING THE PROPOSED INTRODUCTION OF NILE PERCH INTO LAKE VICTORIA

By A. M. Anderson, Game and Fisheries Department, Entebbe, Uganda

(*Received for publication on 1st October, 1960*)

The suggestion has been made by Fryer (1960) that the proposals to introduce Nile Perch into Lake Victoria are based on ignorance of several fundamental biological concepts, and that both theoretical reasoning and practical experience suggest that such an introduction would jeopardize the existing commercial fishery on Lake Victoria. It has also been suggested that the proponents of the idea have based their recommendations on empirical opinions which are unsupported by factual data.

The idea that Nile Perch be introduced to Lake Victoria is no new one, it was first considered by Graham (1929) and by Worthington (1932), and it has recently been put forward by Beverton (1959). In all these cases the proposals originated from the observations that there existed in Lake Victoria, both in the inshore waters and in the deeper offshore waters, vast populations of *Haplochromis* which were hardly utilized and that it might be advantageous to introduce a predator, particularly one of high food value such as the Nile Perch which would do so. During the course of his survey on Lake Victoria, Graham obtained catches of up to 2,600 *Haplochromis* in an hour's trawling in all depths up to 200 ft., and such was their abundance that he expressed the opinion that an industry for *Haplochromis* might support a fleet of 200 trawlers. More recent experimental work carried out by the East African Fisheries Research Organization has shown that catches of up to 200 lb. of *Haplochromis* can be obtained in a half-hour trawling period. The establishment of an industry to exploit these *Haplochromis* populations would only be justifiable if they could be caught and processed at an economic price and utilized as fish meal. The recent drop in world prices for this commodity resulting from increased catches from sea fisheries is unlikely to make this an economic proposition. It seems clear that the obvious way to utilize *Haplochromis* is to introduce a predator which will convert them into something worth while, and the most suitable predator appears to be the Nile Perch. Other benefits would result from the introduction of Nile Perch.

For many years the *Tilapia esculenta* populations throughout the shallow waters of Lake Victoria have been heavily exploited by the use of 5-in. gill nets. In 1956 the regulations in certain territorial waters were changed to permit the use of smaller sized gill nets. There is still considerable controversy as to the wisdom of this move, some authorities maintaining that these small meshed gill nets will capture immature *T. esculenta,* and others, that only a small proportion of these immature fish will be caught, and that any damage done to the *T. esculenta* population will be more than compensated for by the increased catches of *T. variabilis,* a species which was too small to be taken in quantity by the 5-in. gill nets. In any event, the emphasis is still on *Tilapia,* whatever the species, and it will continue to be heavily exploited. It is considered that the Nile Perch would, if established in Lake Victoria, provide an additional food fish of comparable value to *Tilapia,* and because of their ability to live in the deeper offshore waters would permit a dispersal of the fishing effort from the inshore waters which are, in certain localities, too heavily fished. Moreover, because of their great size range which allows them to be captured in a variety of gear, their presence would bring about an extension of the present fishing methods and allow the introduction of 8-in. and 9-in. gill nets, a greater use of long lines and the possible establishment of a troll line fishery, thus again removing the pressure from the *Tilapia.* To serve their purpose they would have to be capable of withstanding heavy exploitation, and experience in other lakes indicates that they can apparently do so.

However, it has been suggested that even to contemplate the introduction of Nile Perch is to display an ignorance of fundamental biological concepts, and yet the very concept of introducing exotic species of fish into established ecological systems is no new one. It is frequently used as a technique of fisheries management, and, as Fryer points out, it is permissible in the case of predators when the removal of "trash fish" is desired. This qualification surely applies on Lake Victoria where, as I have pointed out, the *Haplochromis* is generally regarded as a "trash fish" of very little value. It is of interest to note that the introduction of Nile Perch into Lake Edward and Lake Kivu was recommended in 1959 by various Belgian scientists who, at that time, were responsible for advising on ways and means of improving fisheries production on these lakes. In the case of Lake Edward the introduction was recommended as a means to control "Les indesirables *Haplochromis*". It is quite obvious that the introduction of exotic species is a practice which must be used with discretion, and this fact has been fully recognized both by the earlier and present proponents of the idea all of whom have recommended in the strongest terms that the introduction of Nile Perch into Lake Victoria should only be considered after the most intensive investigations. It has been officially recommended that these investigations should be carried out by the East African Fisheries Research Organization.

Despite the cautious approach adopted by these authorities, Fryer (1960) has condemned the proposed introduction out of hand, and has expressed the opinion that in the final analysis the investigations will be worthless from the point of view of determining whether the introduction should, or should not, take place. Such an attitude indicates a lack of appreciation of the very real problems affecting the commercial industry, and of the difficulties which confront those responsible for its management and development. It seems strange that the sea lamprey, which is, in any case, an anadromous fish of parastic feeding habits, and of no value whatsoever, should be compared to the Nile Perch. It is also strange that in condemning the proposals no attempt has been made to evaluate the factual data which already exists concerning the Nile Perch. It must be admitted that this data relates to waters other than Lake Victoria, nevertheless it would appear to be considerably more relevant than the theoretical arguments submitted, or the hypothesis that conditions in temperate climate lakes are necessarily applicable in the lakes of tropical Africa.

Let us consider what factual data does exist. Firstly, it is necessary to justify the assertion that Nile Perch are a desirable food fish of high economic value, and that they contribute significantly to the overall production in certain lakes. We know that they occur in Lake Albert, Lake Tanganyika and Lake Rudolf. It is an indisputable fact that in the areas adjoining these lakes, and indeed in areas many hundreds of miles away from them to where they are exported, they are held in high esteem as a food fish and command the highest prices both in the fresh and processed condition. In Lake Tanganyika some 5,000 tons of Nile Perch are landed annually in the Congo waters, and although figures are not available significant quantities must also be landed from the Tanganyika waters. In Lake Rudolf, although the commercial fisheries are small in extent, Nile Perch are a significant feature of the catches and experimental fishing carried out on that lake by various expeditions has confirmed their abundance. In Lake Albert about 3,000 tons of Nile Perch are landed annually in the Congo waters and this constitutes about one-third of the total production from these waters. Current production in the Uganda waters of that lake totals about 3,000 tons per year and this again is about one-third of the total production. I think, therefore, that we have satisfied one set of conditions which we wish to duplicate on Lake Victoria, namely, a predatory fish of high value which will withstand exploitation and which will contribute significantly to total production.

It is also necessary to justify the claims that the establishment of Nile Perch in Lake Victoria would improve the fisheries by permitting an extension of the present fishing grounds, and the use of a wider variety of gear. A study of catch records of nearly 5,800 tons of Nile Perch landed in the Uganda waters of Lake Albert over a period of three years shows that the catch was distributed approximately over the various gears as follows:—

TABLE I

TONNAGES OF NILE PERCH LANDED BY VARIOUS GEARS ON LAKE ALBERT

Gear	*Tons*
Long lines	1,590
9 inch gill nets	350
8 inch gill nets	1,540
5 inch gill nets	690
Seine nets	1,600

The long line figures are particularly interesting as this type of gear cannot help but appeal to the fishermen having a higher production to cost ratio than gill nets. No mention has been made of figures for a troll-line fishery as at present this method is practised only by anglers.

However, given the right conditions yields by this method can be high, as much as 600-800 lb. of fish for two lines fishing for an eight-hour period, and there is no reason why African fishermen should not adopt it in the same way that it has been adopted by the Pacific coast salmon fishermen and others; it is also a method which has a higher production to cost ratio than gill netting or seine netting, and would be particularly applicable in Lake Victoria since a considerable number of fishermen on that lake already possess outboard engines. That Nile Perch inhabit the deeper offshore waters is well known. Experimental fishing carried out over a two-year period by the Fisheries Officer on the Uganda waters of Lake Albert has shown that 5-in. gill nets set on the bottom in depths up to 200 ft. will catch about 51 lb. of fish per 100 yards of net, and that 33 per cent of the catch is Nile Perch. 8-in. gill nets in the same locality catch about 45 lb. of fish per 100 yards of net and 83 per cent of this catch is Nile Perch. The phenomenon is also apparent on Lake Tanganyika where Nile Perch are caught in considerable quantities in ring nets operated up to 10 miles offshore in waters which are about 500 ft. deep. It appears that the Nile Perch might therefore satisfy the second set of conditions which we require.

The main objection to the introduction of Nile Perch into Lake Victoria is that they might jeopardize the existing *Tilapia* fisheries. No such phenomenon is apparent on Lake Albert. Beach seines and 5-in. gill nets are operated extensively in that lake, and both gears are used in the inshore waters where one might expect to notice a reduction in *Tilapia* stocks resulting from the presence of Nile Perch. An examination of the catch records of 2,771 seine net hauls on that lake taken over a period of six years shows that 28 per cent of the catch consists of *Tilapia,* and 6.4 per cent is Nile Perch. That the species of *Tilapia* endemic to Lake Victoria and Lake Albert are different is admitted, but this in itself is hardly sufficient reason to account for the favourable balance. A similar pattern is noticed in the records of the 5-in. gill nets, and a consolidation of the records of 10,424 nets shows that 41.5 per cent of the catch was *Tilapia,* and that 3.7 per cent was Nile Perch. To what extent the Nile Perch have depressed the potential *Tilapia* catch, if any, is impossible to say, but the *Tilapia* fishery is still significant. Moreover, because of their larger size an overall 5.5 per cent abundance of Nile Perch does in fact represent 22.6 per cent of the total weight of fish landed by these gears, and the Nile Perch, being of comparable value to the *Tilapia,* have compensated for any of their reputed predation on *Tilapia.*

Interesting evidence is obtained from the results of a preliminary trial to determine the effect of the introduction of Nile Perch on an established population of mixed *Tilapia* which was carried out at Kajansi Fish Farm. In January, 1958, some 400 *T. zillii, T. leucosticta* and *T. nilotica* were introduced into a two-acre pond which was rectangular in shape, and which varied in depth from 1 ft. to 4 ft. In September and October, 1958, 58 Nile Perch which ranged in size from 37 cm. to 65 cm. were introduced to the pond, 38 of these fish had been bred at Kajansi, and 20 had been brought from Butiaba on Lake Albert. Some time prior to April, 1959, probably soon after their introduction to the pond, the Nile Perch bred, and in April, 1959, the first Nile Perch were recovered which were smaller than those originally stocked. From then on it was always possible to obtain a few Nile Perch from the pond measuring 8-10 cm. in length.

In June, July and August, 1959, it was, unfortunately, necessary to remove 122 Nile Perch which were required for stocking purposes elsewhere, but over 50 of these were small fish in the 10-20 cm. range. The trial was continued until March, 1960, when a start was made to fish the pond out and to drain it. Between March, 1960, and July, 1960, 74 Nile Perch were removed: of these, 50 were in the size range 20-58 cm. During the same period some 330 *Tilapia* measuring between 20 and 29 cm. were recovered, in addition to approximately 25,000 *Tilapia* fry. It would appear from these preliminary results that neither the adult or juvenile Nile Perch have any significant effect on the population structure of the *Tilapia,* even under these conditions when there were no other species of fish available as prey, this fact being confirmed at the time of draining. It was noted that a number of large *T. nilotica* weighing up to 2 lb. were recovered from the pond, and this increase in the size of *Tilapia* is also apparent in other ponds where Nile Perch have been stocked. The trial is to be continued under more controlled conditions.

Fryer (1960) condemns the validity of data from other lakes, and his objections to the proposed investigations are based partly on the concept of the Eltonian Pyramid from which he argues that the Nile Perch, being a predatory fish, could not be expected to yield good catches in Lake Victoria. However, as I have tried to demonstrate, the Nile Perch landings on Lake Albert constitute about one-third of the total production, and large quantities are also landed on Lake Tanganyika. Fryer (1960) also maintains that in a gill net fishery where nets are set at random the chances of catching a single Nile Perch are the same as those of catching a *Tilapia.* This cannot be, for a roving predator such as the Nile Perch will always be more susceptible to capture than the Tilapia which are comparatively restricted in habitat. Furthermore, as already mentioned, the ability of Nile Perch to inhabit the deeper offshore waters means that a virtually selective unit fishery could be established to exploit them. Moreover, surely it is a recognized fact that nearly all the major fisheries of the world are based on the capture of predatory fish. That the predator must be in balance with its prey, and that the conversion rates necessitate at least a 5 to 1 ratio (prabably more) of prey to predator, is well known. Here again, the conditions would appear to have been met on Lake Albert, for if they had not been, the Nile Perch would not be so abundant as they are. The question now arises as to whether similar conditions might be applicable in Lake Victoria, and this brings us to a consideration of the feeding habits of Nile Perch.

The opponents to the suggested introduction assume that the Nile Perch will feed almost exclusively on *Tilapia.* Such an assumption is not supported by the preliminary study of their feeding habits which has been made on Lake Albert. The stomach contents of 677 Lake Albert Nile Perch have been examined: of these 211 were empty, a common phenomenon. The information obtained concerning the remainder is shown in Table II and is presented in its simplest form.

TABLE II

THE OCCURRENCE OF FOOD SPECIES IN 466 NILE PERCH STOMACHS

Species	No. of occurrences	Percentage of occurrence
Hydrocyon forskali	74	15·8
Alestes spp.	84	18·0
Tilapia spp.	92	19·7
Engraulicypris bredoi . .	13	2·7
Other Species— *Mormyrus Lates, Haplochromis, Synodontis* . .	31	6·6
Unclassified fish remains . .	133	28·5
Vegetable matter	13	2·7
Insects	26	5·5

The table gives an indication of the wide variety of fish utilized as food. A somewhat similar pattern was obtained by Hamblyn (1959), who recorded that of 216 fish examined 104 were found to contain food which could be identified as *Tilapia, Haplochromis, Alestes, Engraulicypris* and *Lates.* He records that *Caridina* and *Odonata* nymphs comprised practically all the other food. The high percentage of occurrence of *Tilapia* in Table II, 19.7 per cent, results from 48 occurrences recorded on three separate days in one locality on Lake Albert, and on these days no other food species were noted in the stomachs examined. This brings us to the question as to what determines the choice of food material of predatory fish. To an extent it must be determined by the size of the predator, and juvenile predators exist on small fish and small organisms. Larger fish, however, have a wider choice at their disposal and there is evidence to suggest that the choice is dependent on availability and abundance. Corbet (1960) concludes that on Lake Victoria, *Bagrus docmac* above 15 cm. in length depend almost entirely on *Haplochromis.* Is this because the *Haplochromis* are more abundant, or is it that the *Bagrus* can detect the subtle difference between *Haplochromis* and *Tilapia*? I think the former conclusion is the more admissible and I would expect that Nile Perch, if introduced to Lake Victoria, would display the same behaviour. The suggestion that it is abundance and availability which dictates the food supply of the predator must also be considered in respect of the Nile Perch which live in the deeper, offshore waters of Lake Albert. No *Tilapia* have been recorded in these deeper waters, and it seems unlikely that the Nile Perch in Lake Albert make a daily foray of as much as 10 miles to the inshore areas merely to feed on *Tilapia,* obviously they depend for their food supply on what is available in the areas in which they live, and this includes nearly all species with the exception of *Tilapia.*

In any examination of the stomach contents of predatory fish the frequency of empty stomachs is significant. Corbet (1960) records that out of a total of 1,389 *Bagrus* stomachs examined, 277 were empty. Hamblyn (1959) records that out of 216 Nile Perch stomachs examined, 112 were empty, over 50 per cent, and the Lake Albert study referred to earlier shows 211 stomachs empty out of a total of 677. Much of this is due to disgorging on capture, but part may be due to rapid digestion. In this connexion it is of interest to note that the stomachs of quite large Nile Perch (up to 50 lb.) often contain a small quantity of *Engraulicypris,* and nothing else. It seems quite clear that such large fish could not live on this intake of food, and one is led to assume that these fish must, when opportunity permits, gorge on dense shoals of these *Engraulicypris* and the extent to which they do so, and the extent to which they depend on this habit, requires further study; such a habit might account for the frequency of empty stomachs, for a mass of small, soft boned *Engraulicypris* would be more rapidly digested than would larger fish.

The presence of such small fish as *Engraulicypris* in the stomachs of Nile Perch would seem to refute the suggestion that *Haplochromis* are too small a prey to be of use to Nile Perch. Contrary to popular opinion the average size of the Nile Perch landed on Lake Albert is quite low, and over the past four years it has worked out at 18.6 lb. To a fish of this size the *Haplochromis* is an ideal prey and, in fact, there is no evidence to suggest that large predatory fish require large prey. Evidence to the contrary is abundant. Trout, even at a large size, depend on insects for the bulk of their food; the great Tuna families consume vast quantities of macroplankton in addition to small fish, and indeed the valuable pole-line fisheries for Tuna depend almost entirely on the availability of colossal quantities of small bait fish such as *Engraulicypris* with which to attract the Tuna schools.

Before leaving this question of food and feeding habits, it is perhaps relevant to consider whether the Nile Perch, by themselves, can bring about all the improvements which are required on Lake Victoria. If they can utilize the *Haplochromis* populations, and can convert them into something worth while, they will have done all that is asked of them. It has, however, been mentioned (Fryer, 1960) that in Lake Victoria phytoplankton is hardly likely to be a limiting factor in the growth of even a high density *Tilapia* population. This presumably means unexploited phytoplankton, and the question arises as to whether the introduction of *Stolothrissa* and *Limnothrissa* which would utilize this surplus phytoplankton might not be considered.

The practice of carrying out "pilot introductions" of Nile Perch has been strongly criticized by Fryer (1960) on the grounds that such introductions can in no way give an indication of their behaviour if introduced into Lake Victoria. These introductions were never intended to provide information which would allow us to predict with accuracy the subsequent behaviour of Nile Perch after introduction to Lake Victoria, but they were intended to provide additional, factual data, which cannot be obtained in any other way and which cannot help but be of use in the final analysis of all the information available. In addition to the preliminary trials carried out at Kajansi Fish Farm, two "pilot introductions" have been carried out.

The introduction into Lake Nabugabo was proposed by Worthington (1932) and in reviewing his proposals (1933) he stated:—

> "All that is necessary, therefore, to test the effect of Nile Perch on the fisheries of Lake Victoria is to introduce the Perch from Lake Albert to Lake Nabugabo, and nature will do the rest. . . ."

I would not support this claim in its entirety, but I would agree with Worthington that the introduction of Nile Perch to Lake Nabugabo would prove two things. Firstly, it would show whether the Nile Perch would establish themselves and breed in the waters of Lake Nabugabo which are cooler than those of Lake Albert, and which are approximately the same temperature as those of Lake Victoria. Secondly, it would show whether the Nile Perch will multiply to such an extent that they exhaust their own food supply, or whether they will strike a natural balance with the other fish. Surely the answers to these two questions are relevant to the whole question of the proposed introduction. Lake Nabugabo is particularly suited to this pilot introduction because it is regarded as an offshoot of Lake Victoria having been closed off from the latter by a sand-spit.

Moreover, the fishes of Lake Nabugabo are essentially those of Lake Victoria (Greenwood, 1958), and although Lake Nabugabo does not contain the complete range of Lake Victoria species, all the species in Lake Nabugabo are also present in Lake Victoria. Nothing further was done to introduce Nile Perch into Lake Nabugabo until August, 1959, when 30 Nile Perch ranging between 10 and 20 cm. were introduced by the Uganda Game and Fisheries Department. There was evidence to suggest that these fish might have been damaged in transit, and a further introduction of 85 Nile Perch was made in May, 1960. No returns have so far occurred.

Lake Kyoga was chosen as the site for a second introduction of Nile Perch, and stockings were carried out on Lake Kyoga and the Victoria Nile system between the Owen Falls Dam and the Murchison Falls on the following occasions:—

TABLE III.—RECORD OF NILE PERCH STOCKINGS IN LAKE KYOGA AND THE VICTORIA NILE

Date	Locality	Number stocked
March 1954	Above the Murchison Falls	5 fish.
Sept. 1955	Below the Owen Falls Dam	47 fish.
Oct. 1955	Masindi Port	102 fish.
April 1956	Below the Owen Falls Dam	41 fish.
July 1958	Masindi Port	282 fish.
May 1960	Lake Salisbury	30 fish.
May 1960	Namasagali	19 fish.
May 1960	Bujagali Falls	30 fish.

Lake Kyoga was chosen because of the similarity of its fauna with Lake Victoria, there being only a slight difference between the two, and according to Greenwood (1958) both Lake Victoria and Lake Kyoga can be recorded as "cichlid lakes", possessing as they do 59 endemic species of cichlids. Support for this introduction was given by the late Director of East African Fisheries Research Organization, who stated that the subsequent data was likely to produce the best answer to the question of their (Nile Perch) introduction to Lake Victoria.

In addition to providing the obvious answers as to whether the Nile Perch will establish themselves and multiply in these waters, it is hoped that the Kyoga introduction will also, in time, provide the answer as to whether fresh and processed Nile Perch will be acceptable to the consumers of Lake Kyoga fish. That lake at present produces in the region of 10,000 tons of fish each year, and this is marketed over a wide area of Uganda and even exported to Kenya. The impact of a "new" species will be watched with interest. Evidence collected so far indicates that the Nile Perch is compared in flavour to *Bagrus* and is highly acceptable.

The collection of data is difficult from an area such as Lake Kyoga, which has a coast line of about 1,000 miles, and where fishing communities are remote and often difficult of access. Nevertheless, returns of Nile Perch have occurred. The first return was made in July, 1958, and by the end of 1959 a total of 138 fish had been recorded in the fishermen's landings. It is considered that these represent but a fraction of the total amount of Nile Perch landed, for commercial catches on that lake are only recorded by the sampling method. The Nile Perch have established themselves in Lake Kyoga and have spread, and they are now being recorded from areas 50 miles away from the nearest point of stocking. They have bred also, and several fish measuring 15 cm. have been recovered. No attempt has yet been made to find fry smaller than this. The largest confirmed Nile Perch so far recorded from Lake Kyoga is one of 53 lb. The task of investigating the feeding habits of the Nile Perch in Lake Kyoga is rendered difficult by the fact that many fish are only recorded during or after processing, but the few stomach contents so far analysed indicate that *Marcusensius* may be heavily utilized.

SUMMARY

1. The introduction of exotic predatory fish is recognized as a technique of fisheries management.

2. Those authorities responsible for the proposals that Nile Perch might be introduced into Lake Victoria are fully aware of the various biological concepts involved, and have recommended that no introduction should be carried out until full investigations have taken place.

3. The present proposals are based on the knowledge that the commercial fishery on Lake Victoria would be improved by the introduction of a suitable predatory fish which in itself is acceptable as a food fish. An analysis of the data which already exists concerning the Nile Perch indicates that these fish might bring about the desired improvements by:—

(*a*) Utilizing the vast *Haplochromis* populations.

(*b*) Permitting an extension of the present fishing grounds.

(*c*) Allowing the use of a wider variety of fishing methods.

4. The available data concerning Nile Perch in those areas where it is endemic is being supplemented by "pilot introductions" into other waters. These introductions will provide information unobtainable by any other means.

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THE CULTURE OF TILAPIA NIGRA (Günther) in PONDS

VI—THE EFFECT OF SELECTIVE CROPPING METHODS ON BREEDING POPULATIONS

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Whilst the techniques we now recommend for growing *T. nigra* in ponds are those based on monosex culture of males only, utilizing either immature males sexed by genital examination, or more simply utilizing mature males picked out on the obvious character of colouration from breeding ponds at intervals, and fattening these, it is nevertheless realized that there are at present a great many ponds and dams in Kenya Colony which are already heavily stocked with mixed breeding populations. In these the fish are usually very overcrowded, stunted in growth and with very few fish of edible size amongst them.

Though quantities of small fish can give heavy yields in terms of pounds per acre, such small trash fish are acceptable as items of food to relatively few of the indigenous people only, though they can be of value both as fertilizer and perhaps as pig food. Nevertheless the major demand is for the larger sizes of pond fish for eating, even amongst the African people.

The usual recommendations for management of such overstocked ponds are either heavy cropping to reduce numbers of all sizes of fish; or fertilization to increase the food supply and hence possibly growth; direct feeding of the fish to increase growth introduction of some predator to control the increase in fish or, as a last resort, complete destruction of all the fish stocks and a fresh start in a controllable fashion. It is now believed that runting and poor growth is entirely a question of increase of population density by breeding, and hence restriction of food supply available, and that actual maturation of fish has no effect on growth except in so far as it leads to breeding (Parts I-V of this series of papers). The population increase due to breeding is usually of very great magnitude and can hardly be compensated for by artificial additives of food supply in small dams in any economic fashion.

Though such remedies may be obvious, and are mainly directed at reducing the population, or eliminating breeding, or increasing food supplies, for *T. nigra* at least the rationale of these has never been established, and such recommendations have been made on an *ad hoc* basis only.

Therefore, as part of the programme on fish culture research at the Inland Fishery Research Station of this Ministry at Sagana, experiments have been conducted on the effect of various methods of selective cropping on overstocked breeding ponds.

METHODS

In the experiments described below, only one method of cropping has been used, that of seine-netting the ponds, using a 75 yd. ½ in. mesh nylon seine. This is relatively unselective for all sizes of fish above 2.0 cm., thus further selection of the fish caught is possible by hand. By contrast, the use of traps, or larger mesh nets used as seines or gill nets, are much more size selective, taking usually only the larger sizes of fish and leaving untouched the great bulk of trash fish which are of much more importance to the pond economy.

Three ¼ acre ponds, all containing clear water and held at a depth of 12-18 in. water were each stocked with 250 mixed males and females taken at random from a seine haul in a large breeding dam. These averaged 8-9 cm. in length and probably represented normal sex ratio in the usual proportions of 60 per cent males, 40 per cent females such as occurs naturally in *nigra* populations (van Someren, 1953).

These were stocked in December, 1958, and four and a half months later, in April, 1959, when considerable breeding had occurred (though probably before the ponds had reached their full holding capacity for fish, van Someren, *loc. cit.*), two of these ponds were seined once a month thereafter for seven months. From one of these ponds, C3, all the large fish were taken monthly, these being practically all the P (stocking) generation of fish. These P fish were counted, weighed and

FIG. 1

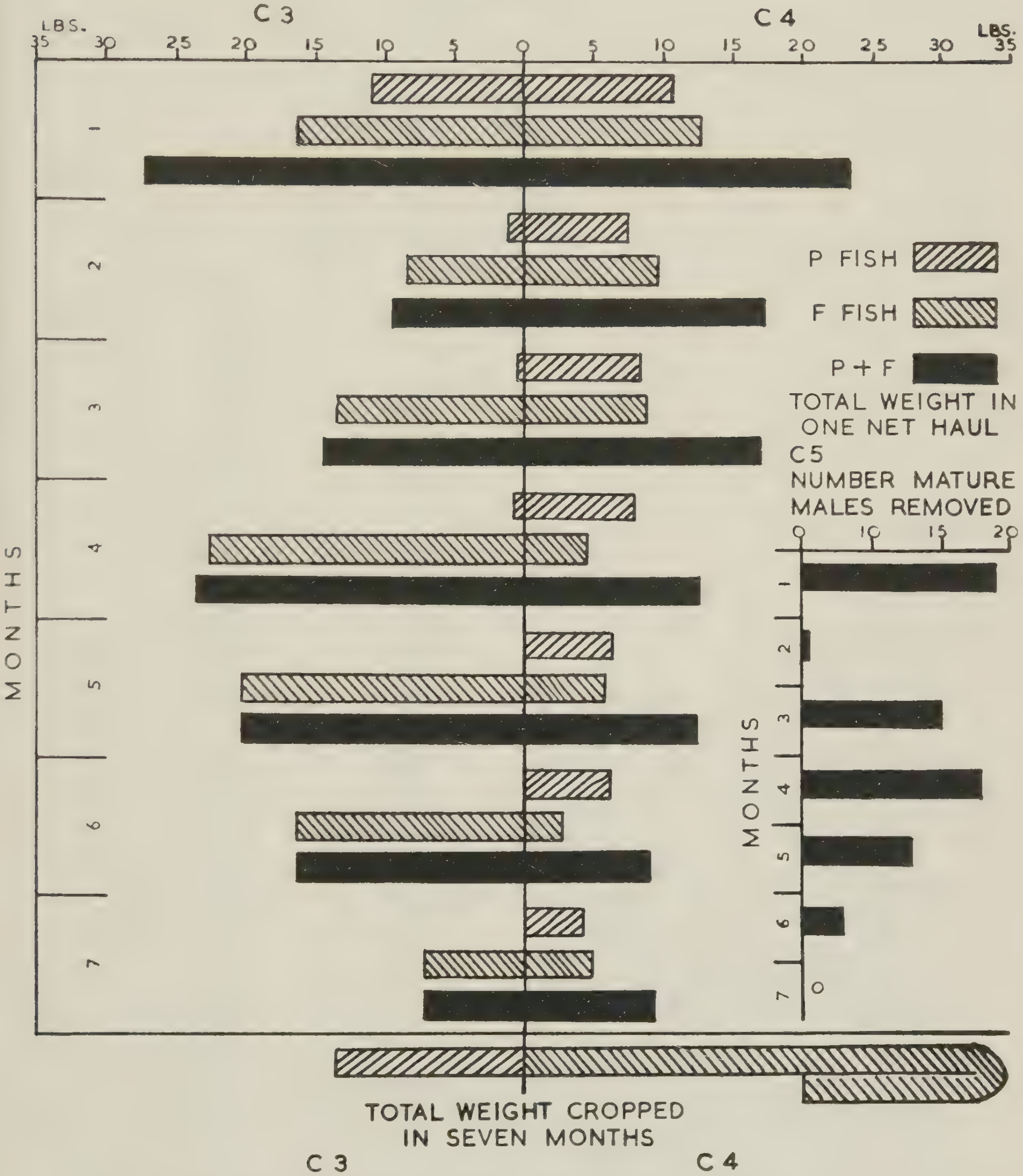

Fig. 1.—The effect of selective cropping methods on a mixed breeding stock of *T. nigra*, shown as weights removed. Pond C3, only P fish cropped; Pond C4, only F fish cropped; Pond C5, only mature male fish removed

killed, all the remaining fry (F generation) fish being weighed in bulk and returned alive to the pond. In the second pond C4, a similar haul was made monthly, but all the P fish were returned alive and all the F fish killed after weighing. Only one haul was made in each pond on each occasion.

The third pond C5 was also seined once monthly as from May, 1959, but from this, only mature males were removed (probably mainly P fish, though a few F mature males were also included); these males were picked out on the basis of breeding colours only and not sexed by genital examination. These were counted, weighed and stocked elsewhere, and all females, immature fish and fry returned alive to the pond without counting or weighing.

In the twelfth month after stocking (eighth after cropping), all these ponds were drained down, poisoned with rotenone and all remaining fish recovered. All the remaining P fish were counted, measured, weighed and sexed; all the F fish were weighed in bulk, random samples taken for length frequencies, and in some cases sex-ratios estimated. A total count of fry was not possible.

RESULTS

The results are represented diagrammatically in Figures 1, 2 and 3.

At the commencement of cropping, it was apparent that both C3 and C4 ponds had reached the same stage of productivity, since one haul in each produced the same result with similar proportions and weight of P and F fish, though as mentioned above it is unlikely that either pond had yet reached its maximum holding capacity, since it takes about eight months of unrestricted breeding to reach a maximum standing crop.

Certain facts can be noted from the results detailed. It would appear that there is at first an increased survival of fry if the P fish are cropped. Though netting efficiency may have varied, there is nevertheless a distinct difference in the pattern of the monthly net hauls. In C3, as soon as all the larger P fish had been removed, greatly increased numbers of fry were at first caught, but these diminished steadily in total weight until finally in the seventh month one net haul produced only a slightly greater weight of fry than a similar haul in C4. This suggests that some density dependent mortality factor had operated to keep the increasing fry survival to some steady level. On the other hand, as might be expected, the weight of fry in one haul in C4 diminished steadily as they were cropped.

Nevertheless, the drainage results showed a greater weight of fry still present in C3; as Fig. 3 shows, these fry survivors were no bigger than in the other ponds, therefore this greater weight must have been made up with greater numbers.

There are two ways of regarding a fish crop as satisfactory; (*a*) the maximum total weight obtainable in a given time, irrespective of fish size, or (*b*) the maximum size of fish obtainable, with perhaps a lesser weight yield. These results show that there is no question that cropping only the larger fish, as in C3, produces neither of these results. In small ponds of such dimensions, all the fish of reasonable individual size are very quickly cropped out even with a once monthly haul. The growth potential of the pond which is thus made available by the removal of these larger fish, is then immediately taken up by the far greater numbers of F fish, which, because they are at a high population density, therefore grow much more slowly than their parents and would probably never reach the size of their parents under such circumstances.

Therefore, cropping by gill-nets or trapping in restricted water areas such as small dams, where the effort per unit area is likely to be very intense, will produce a smaller total weight of large sized individual fish for only a limited period since they are selective of these large sizes only. These large fish will become increasingly scanty in numbers, since in the ordinary farm dam their final size is limited; their removal at the same time leads to a yet higher survival of their progeny, which because of this higher survival and thus denser population, will never attain the same size, and thus it is to be expected that the supply of large fish will eventually cease altogether where such methods are used.

As a corollary, a similar state of affairs will also prevail if the pond is not fished at all, for the P survivors will gradually diminish in numbers through natural mortality, and their place will be taken again by much greater numbers of F fish which will remain smaller. This is the situation evident in most overstocked dams.

If on the other hand, the smaller F fish are consistently heavily fished out as in C4, not only is the total weight of protein produced much greater on both a cropping and a sur-

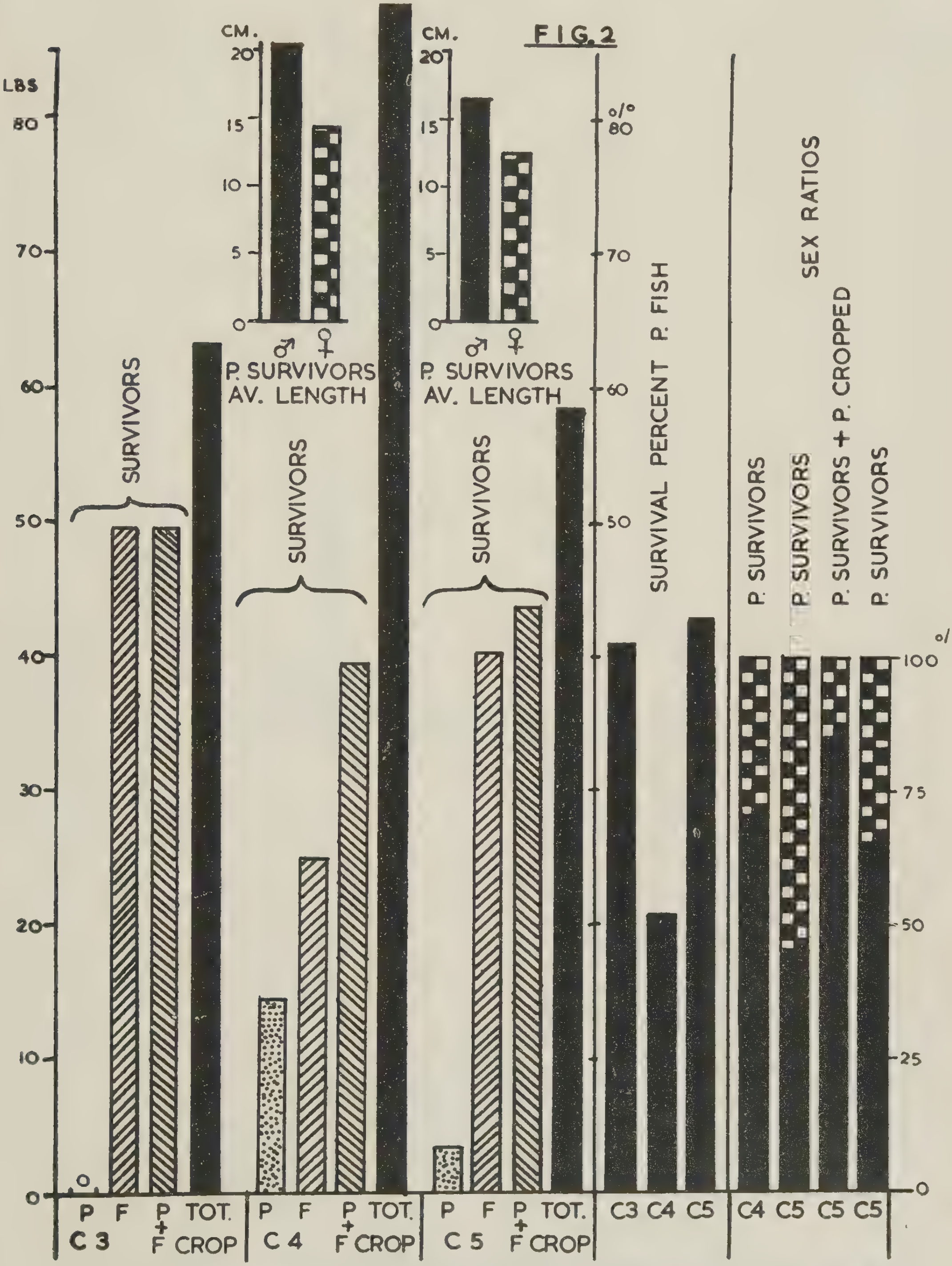

Fig. 2.—The effect of selective cropping methods on a mixed breeding stock of *T. nigra*. Data from the survivors recovered after total drainage of each pond. Pond C3, only P fish cropped; Pond C4, F fish cropped; Pond C5, only mature male fish removed

vivor basis, but also the P fish attain a larger individual size. Once, however, these are cropped also, the pond will revert to its first state again unless the F fish are very considerably reduced in total numbers and only a very small number of the larger F fish are left to attain P size once more. Therefore, cropping of F fish should be directed at removing the smaller of the F fish in greater quantity than the larger ones in order to allow the latter to attain a larger size. Such must be a continuing process, and it seems likely that at least in such a small pond, one net haul would allow of sufficient escapement; but the striking of the correct balance must be rather precisely judged.

While it is true that such extraction of small fish both over a period of time and at any one time, produces a greater weight of fish, the problem still remains as to how such trash fish might usefully be disposed of. Their extraction is desirable on all grounds in mixed breeding ponds, and as is shown, they may total some 400-500 lb. per acre in such unfertilized, unfed ponds. Use as fertilizer or pig food are two obvious choices; their quantity would not be sufficient in the usual dam for production of fish meal, where reduction of weight on extraction and drying leads to losses of some 80 per cent on harvested weight.

It is possible that small ponds would require resting from cropping from time to time to allow stocks to build up again as regards the size and weight of larger fish left, but two months should be ample in a pond as small as $\frac{1}{4}$ acre.

The present monosex culture technique recommended is that of taking mature males, distinguishable on colouration only, from mixed breeding ponds and fattening them separately in other ponds by themselves. It is interesting therefore to see how often such a procedure can be repeated from a mixed breeding pond. It was suspected (Part 1 of this series) that such sex selective cropping methods could be repeated almost indefinitely, since aquarium experiments (E.A.F.R.O., 1959) seemed to indicate that in other species of *Tilapia* assumption of breeding colouration by males in tanks was limited by the space available, and that some form of social dominance was a major factor, as in many other animals. It was found that as soon as a male in full breeding dress was removed from a mixed shoal in an aquarium, another coloured up to take its place.

The present results from C5 showed that after four months, 19 mature males could be removed at one net haul from a $\frac{1}{4}$ acre pond, the rest being still immature; this suggests a spacing of one mature male per 20 square yards of bottom—a figure possibly on the low side, since not all of the pond bottom is necessarily available for breeding.

It was two months before a similar quantity of mature males could be further removed, the supply of such lasting for another four months. It was also apparent from the results on draining that a further one month's rest would have been necessary before other males coloured up, since the draining showed a great many males almost on the point of maturity, both among the remaining P fish and amongst the larger F fish.

Although *T. nigra* appears to breed most of the year round, there are peak periods during which greater numbers of mature fish are found; May-June is undoubtedly one such period, and there may be others not yet fully established. Therefore, the supply of mature males for such a technique is likely to be somewhat seasonal, but would apparently be almost inexhaustible as long as a few are left each month to breed. As the P males are taken out, so the larger F males begin to colour up and mature at a smaller size as was found in this experiment, and these are just as satisfactory for fattening, though they may take somewhat longer, starting as smaller fish. On a monthly average, these results indicate that perhaps 44 males in breeding dress could be taken monthly per acre, if simple multiplication by surface area is valid; it may in fact be a much higher figure in practice.

It is moreover interesting to note that since the natural sex-ratios of unrestricted *T. nigra* breeders show a preponderance of males, such selective cropping by sex colouration appears in the case of C5 to have done no more than reduce the sex ratio to parity or slightly less; there is thus by no means a total extraction of all males.

Other experiments have already suggested that a greater fry production can be expected when in fact males are outnumbered by females, since one male can apparently fertilize several females over a short period of time. Therefore reduction of the sex ratio to parity would in the end lead to more fry, and hence more males in the end. This is indicated in Fig. 2, where C5 shows a higher total weight of survivors, i.e. P fish plus F fish, than in the

FIG. 3

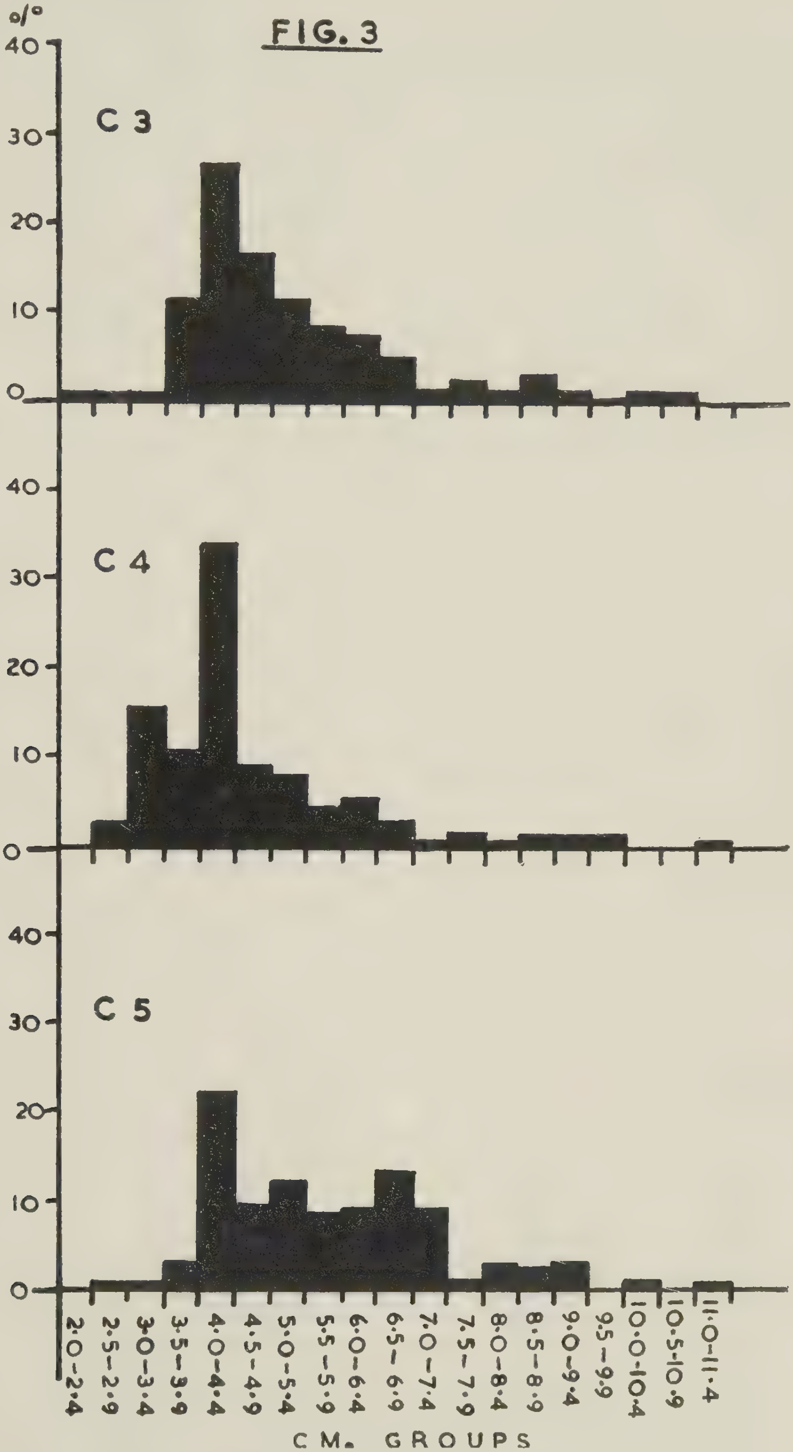

Fig. 3.—The effect of selective cropping methods on a mixed breeding stock of *T. nigra*. Length frequency data for the F fish survivors recovered after total drainage after seven months' cropping. Pond C3, only P fish cropped; Pond C4, only F fish cropped; Pond C5, only mature males removed

other two ponds, and the sex ratio is again normal in the F fish with a preponderance of males. Sex ratios of the P fish calculated on that of survivors plus crop show in fact a higher than normal preponderance of males, but this is probably due to the fact that some of the mature male crop taken were in fact the larger F fish, forced into earlier maturity by removal of their mature male parents.

It is of interest to note also that the P males and females in C5 still averaged less in length than those in the pond from which the F fish had been cropped. This is an indication of depression of their growth by the larger fry in C5 which had not been cropped, conjointly perhaps with the fact that the larger (mature) males had in any case already been taken, though this would not explain the discrepancy in the size of the females. Female *nigra* are always smaller than males.

SUMMARY

It is shown that cropping only large fish from a mixed breeding pond will in time lead to a diminution in availability of such large fish, not only because they have been cropped, but also because it leads to a greater survival of fry which in turn leads to a denser population and therefore less growth of individual fish. The larger of the fry left under such cropping will never attain the former size of original stock fish.

By contrast, cropping of fry only, leads to much greater total weight yields, though the majority of fish taken are of relatively useless trash size. It also leads however to a greater increase in size of the larger fish left.

Cropping of mature males only on the basis of breeding colouration, these to be used for fattening in monosex ponds elsewhere, can be carried on perhaps for very long periods, since as breeding males are removed so others colour up to taken their place. Indications are that up to 44 coloured males per acre per month could thus be cropped and such cropping does little more than reduce the normal preponderance of males in the normal sex ratio to parity with females. It probably leads also to higher fry production, and thus more males still over a long period.

For the culture of good sized *Tilapia nigra* therefore, a two-pond technique is recommended. In one of these mixed breeding is allowed to occur freely; from this mixed pond mature males are removed periodically on the basis of breeding colouration, and these are then fattened separately for marketing or consumption in another pond in which such males only are kept in monosex culture.

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Table 1

POND C3	POND C4	POND C5
Method Cropping P (stocking) fish only once monthly, one net haul.	Method Cropping F (progeny) fish only, once monthly, one net haul.	Method Cropping mature males only in breeding dress, once monthly, one net haul.
First Haul Weight 27·0 lb. (P + F).	First Haul Weight 23·5 lb. (P + F).	
Crop Bulk of stocking fish removed at first haul, thereafter in only very small numbers, and none after fourth month cropping. All fish taken at very small size, about 15 cm. No F fish attained this size in subsequent months. *Total Crop Weight* . . 13·6 lb.	Crop Largest weight of F fish taken in first haul, thereafter in declining weight each month, although many still available at end of experiment. None larger than 10·0 cm. *Total Crop Weight* . . 49·8 lb.	Crop Largest number of mature males removed in first net haul. Thereafter about one months' delay before others available, then numbers declining again to seventh month. *Total Number Mature Males removed.* 77. Average 11 per cent per $\frac{1}{4}$ acre.
Survivors *P fish.*—No P survivors found. Total survival from first stocking (as cropped fish), 41 per cent. Sex-ratio not examined. *Total Weight.*—F fish only 45·5 lb. *Total Yield.*—Crop + survivors 59 lb. *F fish.*—Survivors of a wide range of sizes up to 10·9 cm., but none attained size of P fish. Scanty in numbers below 3·4 cm. group size, probably because no P fish left to breed such. 4·0–4·4 cm. group dominant.	Survivors *P fish.*—Survival 20 per cent after 12 months, total weight 14·5 lb., males averaging 20·0 cm. Sex ratios normal, 70 per cent males. *Total Weight.*—P + F 39·5 lb. *Total Yield.*—Crop + survivors 90 lb. *F fish.*—Survivors of a wide range of sizes up to 11·4 cm., but none attained size of P fish. Groups above 4·5 cm. more scanty than in other two ponds. By contrast, groups below 3·5 cm. more abundant, as these are bred by the P survivors and are too small to be caught by $\frac{1}{2}$ inch seine. 4·0–4·4 cm. group abundant.	Survivors *P fish.*—Survival 43 per cent after 12 months, total weight 3·5 lb., males averaging 16·5 cm. Sex ratios, males reduced to 40 per cent in survivors. *Total Weight.*—P + F 45 lb. *Total Yield.*—Crop + survivors 58·5 lb. *F fish.*—Survivors of a wide range of sizes up to 11·4 cm., but none attained size of P fish. Groups of 4·5–7·4 cm. abundant, possibly this abundance of larger fry significant, as they would have greater foraging area when territorial breeding males are removed. Groups below 3·4 cm. scanty as possibly insufficient mature males left to breed such. Sex ratio of F fish, normal, 65 per cent males.

THE CONTROL OF STEM RUST IN WHEAT (Puccinia graminis var. tritici) BY AERIAL APPLICATION OF FUNGICIDES

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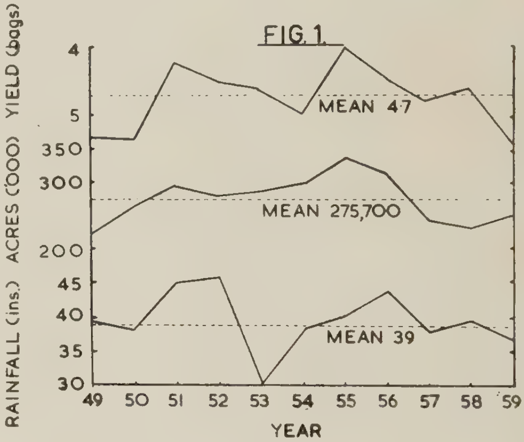
Black Stem Rust of wheat (*Puccinia graminis* var. *tritici*) is acknowledged to be the major disease of wheat in Kenya. Its presence in wheat crops each year results in low yields and poor grade. It has been the object of plant breeders for the past half century in Kenya to produce wheats which are resistant to the disease and which also have good baking qualities. The breeding of such wheats has been a difficult task due to the "short circuit" in the life history of the fungus under Kenya conditions. Guthrie, 1959, has pointed out that the lack of a winter, together with a wide range of growing seasons in East Africa, makes it possible for the fungus to survive in the uredospore stage throughout the year. In addition, new strains of the fungus are constantly appearing either through mutation or by transport in the wind from other countries further north. This constant influx of new races is a curse to the plant breeder, each year many promising new "varieties" succumbing to the new and often more virulent strains of the fungus.

Figure 1 shows the position with regard to average yields of wheat, acreage planted and rainfall over the past 11 years in Kenya. The rainfall figures from Eldoret were chosen since Eldoret lies in the largest wheat producing area of Kenya—the Uasin Gishu—with a production of approximately 500,000 bags annually out of a total for Kenya of approximately 1,400,000 bags.

It will be seen from the graphs that the yield per acre appears to vary inversely with the two factors of rainfall and acreage planted. High rainfall years are invariably associated with high levels of rust so influencing yields adversely. Secondly, an increase in acreage often means that marginal land or marginal areas are being cropped to wheat. A reduction in the acreage is usually associated with an increase in the average yield per acre, this being accounted for by the exclusion from cropping of the more marginal wheat lands.

The mean yield of 4.7 bags per acre over the past 11 years is indeed a low one and no upward trend during this period is in evidence in spite of improved technical knowledge through agricultural extension work and the selection and breeding of new wheat varieties. It appears, therefore, that plant breeding has only enabled average yields to be maintained. This, however, is no mean achievement as the change in varieties grown by farmers over this period would show.

FIG. 1



Important as plant-breeding is, however, alternative methods of controlling the disease cannot be ignored in a country like Kenya where the repeated failure of new varieties to stand up to attacks of new strains of the fungus is only too well known.

Chemical methods of control have been tried in the past on small experimental plots using elemental sulphur and later zineb (zinc dithiocarbamate) These methods gave some control if applications were started early in the growth stage of the plant and continued at intervals of approximately ten days until harvest. The methods were, however, impracticable on a field scale.

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Chemical methods of control if efficient, can increase yields in several ways: directly, by controlling the disease or indirectly, by enabling high yielding wheats to be bred and used or by enabling nitrogenous fertilizers to be used without fear from an increased rust attack. For such methods to be practical to the farmer they must be economic and capable of application on a field scale to growing crops.

In 1958 it was decided to attempt rust control by applying fungicide by air in low volumes of water per acre. Ground applications were considered to be impracticable because of loss of crops by tractor damage and the impossibility of using wheeled tractors during the rainy season, particularly on the black and grey clays.

1958 ZINEB TRIAL

The short rains season at Naro Moru, Kenya, was selected for the trial for two reasons: the growing season is a short one (4½ months) and the mornings are dry and sunny, so enabling the fungicide to dry on the leaves for several hours before rain may be expected. Three varieties were used in the trial: H.462, a quick growing bearded variety which at the time was considered "safe" as far as Stem Rust was concerned; 339, known to be susceptible to Yellow Leaf Rust (*P. glumarum*) but a fairly safe variety as far as Stem Rust was concerned; and 294.B, a variety known to be highly susceptible to Stem Rust though with a high yield potential in the absence of Rust.

All varieties were planted on 27th September, 1958, with a combine seed drill, together with 100 lb. of triple superphosphate as a fertilizer dressing. H.462 was planted at a seed rate of 100 lb. per acre because of its low tillering ability, and the other varieties at 80 lb. per acre.

It was decided to use the zineb at the recommended rate of 2 lb. per acre in water. One fluid ounce of a proprietary wetting agent (Alboleum) was added to every gallon of fungicide to act as a spreader. Since no other work had been reported in which low volumes of water had been used for aerial applications of fungicide for rust control, the level of five gallons per acre was chosen as being the maximum economic quantity to be applied by plane.

Strips were demarcated in the field to receive the sprays, together with adjacent control plots. By cross-spraying the field for the last two sprays, the following treatments were obtained:—

*H.*462	339	294.*B*
(1) 4 early sprays.	(1) 3 early sprays.	(1) 3 early sprays.
(2) Control.	(2) Control.	(2) Control.
(3) 6 sprays (early + late).	(3) 5 sprays (early + late).	(3) 5 sprays (early + late).
(4) 2 late sprays.	(4) 2 late sprays.	

The H.462 received four early sprays and not three because the wheat was so quick and had to be sprayed before the others. The absence of treatment (4) for the variety 294.B was due to the shape of the particular field.

The aircraft used in the trial was an adapted Boeing Stearman P & W.450. Using D.10 jets (10/64th in. diameter), 18 in number, and flying at a ground speed of 75 m.p.h., an emission rate of five gallons per acre was obtained.

Spraying dates and rainfall figures for the date of spraying are as follows:—

Spraying Date	*Rainfall* (*in.*)
19–11–58 (H.462 only)	Nil
28–11–58	0·07
10–12–58	0·02
20–12–58	0·02
7–1–59	Nil
20–1–59	Nil

The total rainfall from planting to harvesting was 15.53 in., the season being regarded as a normal one.

Observations

Yellow Leaf Rust began to attack the variety 339 at the five-leaf stage and a heavy attack was present by the date of the first spraying. The H.462 began to be attacked with Yellow Leaf Rust on 19th November, 1958, and developed appreciably by the time the wheat was in head. The 294.B, on the other hand, remained relatively free of Yellow Leaf Rust throughout.

By 9th December, small pustules of Black Stem Rust began to appear on the 294.B and 339, and by 20th December, when both these varieties were flowering, Stem Rust was heavy. By this time Yellow Ear Rust (*P. glumarum*) was attacking the H.462, but there was no sign of Stem Rust. From the end of December to harvest the Stem Rust increased in severity on the varieties 294.B and 339, so that by harvest the 339 was very heavily attacked and the 294.B severely attacked. Black Stem Rust was late appearing in the H.462 and was so slight as to have had little effect on the yield.

The dates of harvest of the three varieties were as follows:—

H.462	February 23rd	i.e. 149 days from planting.
339	March 18th	179 ,, ,, ,,
294	March 20th	174 ,, ,, ,,

Results

Even after only two sprays the plots of 339 and H.462 could clearly be distinguished from their controls, both from the air and from the ground. This was due to the marked control of Yellow Leaf Rust in the sprayed plots. In the H.462, both Yellow Ear Rust and Glume Blotch (*Septoria nodorum*) were less in evidence on the sprayed plots. The sprayed plots of 294.B showed less Stem Rust than the controls but even so were still heavily attacked. The rust did not, however, reach the actual heads of wheat as it did in the control plots.

The yield data are shown in Table I.

TABLE I

Treatment	Acreage	Yield in lb./acre	Percentage of control	Grade	Moisture	Value
					%	
H.462—						
(1) 4 early sprays ..	3·23	1,204	122	59(3)	14·4	296/60
(2) Control	3·25	990	100	58(3)	13·0	243/88
(3) 6 sprays (early and late)	0·33	1,512	153	60(2)	13·5	379/96
(4) 2 late sprays	2·09	1,198	121	61(2)	13·3	301/05
339—						
(1) 3 early sprays ..	4·87	781	113	54(5)	13·7	190/40
(2) Control	4·87	689	100	54(5)	15·2	167/97
(3) 5 sprays (early and late)	0·33	851	123	56(4)	15·6	214/70
(4) 2 late sprays	2·63	872	127	56(4)	17·5	220/-
294.*B*—						
(1) 3 early sprays ..	9·65	454	344	54(5)	13·2	121/92
(2) Control	3·67	132	100	53(6)	14·7	33/58
(3) 5 sprays (early and late)	0·63	359	272	54(5)	15·9	96/40

It will be seen that in every case the sprayed plots outyielded the controls. Two late sprays were as good as, or even better than, three or four early sprays. With H.462 the early plus late sprays gave by far the best yield. This was to be expected but was not shown to be the case with the 339 and 294.B. The area involved, however, was quite small and, during harvesting, these small plots were badly lodged. It was noticeable at harvest that the straw of the sprayed plots was a much brighter yellow than that of the unsprayed plots due to a reduced secondary fungal attack. Sprayed plots (except for the early sprays on 339) yielded grain which had a higher bushel weight and therefore a higher grade than did the unsprayed controls. The grain, particularly in the case of H.462, was also much brighter in appearance.

It will be noticed that yields of both 339 and 294.B, particularly the latter, are very low. Although the percentage increase over the control is greater with 294.B, because the variety is so very susceptible to Stem Rust, the yield of the sprayed plots is still too low to be economical. The results of the trial do not, therefore, support the view that high yielding premium wheats can be grown successfully by the use of zineb as a fungicide when applied at the rates used in the trial. The results on wheat relatively resistant to Stem Rust are, however, encouraging, though not economical at present prices.

1959 O-3818-B TRIAL

In 1959 a new chemical produced by the Rohm & Hass Company of Philadelphia became available for testing as a spray material for the control of Stem Rust. O-3818-B is a mixture of the nickel and zinc salts of ethylene bisdithiocarbamate, containing approximately

15 per cent Zn and 7 per cent of Ni. Under laboratory conditions it has been shown to be effective as an eradicant and as a protectant against both Yellow Leaf Rust and Stem Rust of rye and wheat.

The recommended rate of 2 lb. of O-3818-B per acre was used in the trial, the quantity being mixed in two gallons of water. The two gallons per acre rate was decided upon as this was the normal rate for applying weedkillers by air and thought to be the minimum one could use to get any effective cover.

A randomized block layout with six replications of two treatments was used. The two treatments were spray versus no spray. Plot size was 100 yards by 40 yards (two swath widths). The same field as was used for the zineb trial was used again but the wheat chosen was Florence Aurore. This wheat was chosen for four reasons: it has a high yield potential under favourable conditions, its baking quality is very high, it is known to be very susceptible to Stem Rust and it is beardless and so would allow greater penetration of the fungicide than if a bearded variety had been used. The wheat was planted with a combine seed drill at 80 lb. per acre, together with 100 lb. per acre of triple superphosphate on 19th September. The seed did not germinate until 15th November with the onset of the rains but grew away well initially.

Plots were demarcated by cutting paths 18 in. wide between the plots, these paths being clearly visible from the air. The plots were so arranged that any drift would pass along the plot being sprayed and not across to unsprayed control plots. In fact no drift problems were encountered.

Spraying occurred three times during the growth of the crop, as follows:—

Date	Stage of Crop	Rust Attack
13–1–60	90% of crop in head	No rust.
29–1–60	Early milk ripe ..	1% of plants attacked.
10–2–60	Early cheese ripe..	95–100% of plants attacked.

The O-3818-B was weighed and mixed with water on the morning of application. No difficulty was experienced in producing a suspension for aerial spraying. A Piper Super Cub (P.A.18A) flying at a speed of 80 m.p.h. on the spray run was used, the spray gear consisting of a boom type sprayer fitted with a high density centrifugal spray pump. D.5 nozzles were used with an aperture diameter of 5/64th in. African assistants indicated the plots to be sprayed by flagging and the spray was applied from a height of about 2 ft. above the heads of the wheat. Some dew was present on the plants at spraying but this soon evaporated and was never as heavy as in the 1958 trial.

Observations

Poor rainfall conditions prevailed throughout the season, the rainfall recorded after planting being as follows:—

Month	Rainfall (*in.*)	Distribution
October	0·31	Very poor.
November	4·24	Good.
December	1·55	Numerous small showers.
January	1·56	Numerous small showers.
February	Nil	
TOTAL	7·66	inches.

The rainfall recorded was less than half that of the previous short rains season and on the whole the distribution was very bad indeed. The crop failed to tiller and suffered from drought from the end of December onwards, Uptake of the spray must have been adversely affected by the droughted condition of the plants.

An attack of the American Corn Ear Worm (*Heliothis armigera*) was noticed on the plots on 29th January but damage was very slight indeed.

Prior to the final spraying on 10th February, 1960, the plots were sampled and pustule counts taken. One hundred plants were selected at random from each of the 12 plots and pustule counts taken on each stem. At the last spraying the crop was 37 in. high and the mean ear length 3 in. The crop was in the early "cheese" ripe stage. Plants in the sprayed plots appeared to have more tightly curled leaves than those in the unsprayed plots but on all plots leaf curl was in evidence as a result of the drought. An opportunity was taken to fly over the plots but no visible differences could be detected. Plots were harvested on 11th March by means of a combine harvester. Five harvester widths constituted a plot, i.e. 55 ft. by 100 yd., and the remaining area was discarded.

At harvest it was apparent that the heads of the unsprayed plots were a darker colour than the sprayed plots. Unsprayed plots were dark coloured or black with secondary fungal attack —probably *Cladosporium* spp.—compared with the bright coloured heads of the sprayed plots. Volunteer barley growing with the wheat was heavily attacked with Net Blotch (*Helminthosporium teres*) and Scald (*Rhynchosporium secalis*) in both seasons. No effective control of these diseases was apparent from spraying with either zineb or O-3818-B.

Results

Table II gives the mean pustule counts per plant from the various plots.

TABLE II

Treatment	Block I	II	III	IV	V	VI	Total	Mean
Control	7·00	8·10	9·26	7·14	7·84	8·24	47·58	7·93
Sprayed	3·86	5·58	7·48	4·92	4·84	4·68	31·36	5·23
Block Totals ..	10·86	13·68	16·74	12·06	12·68	12·92	78·94	6·58

Standard error of a single plot = 0·462
Coefficient of variation .. = 7·0%

Spraying resulted in a highly significant though relatively small reduction in the number of Stem Rust pustules per plant. This reduction amounted to 34 per cent as a result of two aerial sprayings. Little or no increase in the rust attack occurred between this count and harvest so no further samples were taken. Table III gives the yields per plot at harvest.

TABLE III.—YIELDS OF GRAIN IN LB./PLOT OF 0·374 ACRE

Treatment	Block I	II	III	IV	V	VI	Total	Mean	Mean/ Acre
Control ..	404	407	398	375	374	371	2,329	388·1	1,037·7
Sprayed ..	419	440	429	400	396	401	2,485	416·1	1,112·5
Block Totals	823	847	827	775	770	772	4,814	402·3	

Standard error of a single plot = 4·78 lb.
Coefficient of Variation .. = 1·2%

A highly significant increase in yield of 74.8 per acre resulted from the three sprayings. This increase was, however, only 7.2 per cent higher than the control yield. Such a small difference was only to be expected with the low level of rust attack encountered in the trial. The coefficient of variation was remarkably low for such a large scale trial.

Bushel weights and thousand grain weights showed similar trends to the yield figures. Analysis of the figures for bushel weights revealed that differences were not statistically significant at the 5 per cent level, significance only being reached at the 10 per cent level. The difference for thousand grain weight were, however, shown to be significant at the 5 per cent level.

Nickel analyses of the grain from sprayed and unsprayed plots were carried out by the Mond Nickel Company. The results are given in Table IV.

TABLE IV

Treatment	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Rep. 5	Rep. 6	Mean	Sign. Diff. 5%
Sprayed (p.p.m.) ..	2·8	4·9	3·1	4·7	4·8	4·1	4·07	0·93
Unsprayed (p.p.m.) ..	1·9	2·3	1·5	1·4	1·9	1·7	1·78	

Standard Error of a Single Plot 0·625 p.p.m.
Coefficient of Variation 21·4%

A highly significant increase in the nickel content of the grain from sprayed plots is evident. The values for the sprayed wheat lie within the limits found by Mitchell (1945) working with pasture plants in Scotland and by Chang and Sherman (1953) who worked with a wide variety of plants in Hawaii. They are, however, far lower than nickel contents recorded by Hunter and Vergnano (1954) for oats growing on naturally occurring nickel toxic serpentine soils in Aberdeenshire, Scotland. The recovery of the nickel in the grain was extremely low, only 0.64 per cent being recovered from the three aerial applications of approximately 0.14 lb. of nickel per application.

DISCUSSION

The trials described above indicate that increases in yields and bushel weights of wheat can be obtained in Kenya by the use of fungicidal sprays in low volume applied by aircraft. Under the conditions of the experiments, however, the responses have not been economic. In the case of the O-3818-B trial, a difference of two bags per acre would have been required to render the spraying economic to the farmer. Such differences may well have occurred had the season been a normal one and had the Rust attack reached its normal severity.

The results do, however, confirm the results of similar experiments in Canada and the U.S.A. Peturson and Forsyth, 1959, have shown that yield increases over controls of the order of 49 per cent to 216 per cent can be obtained with zineb. Their experiments indicated that high volume sprays were not necessarily better than low volume applications. In their 1957 experiments application rates of five and ten gallons per acre (from the ground) gave better results than the 50 and 100-gallon rates, the 50 and 100-gallon rates giving yields not significantly different from the control plots. In the 1958 experiments there was no significant difference between spray treatments, although sprayed plots significantly outyielded the controls. They concluded that the rust control fungicides used were just as effective, if not more effective, when applied in low volumes of water than when applied in high volumes. Shroeder *et al.*, 1959, working on tomato diseases, found that gallonage was not necessarily the main determinant of a good fungicidal schedule provided the fungicide dosage per acre is constant, dosages as low as 20 gallons per acre resulting in yields not significantly different from the 200 gallonage rate. Applications of fungicide in low volume by air would not, therefore, appear to be a serious problem in the extension of aerial spraying on a large scale. The gallonage per acre limit set by the utilization of aircraft may well be as efficient as other methods of application provided adequate cover can be achieved by correct formulation of the spray and the use of efficient spraying mechanisms. The coverage in the experiments described was poor, particularly with the two gallon application rate. It is felt, however, that these techniques can be improved by further experimentation with the use of spreaders and nozzles.

The production by Rohm & Haas Company of the fungicide O-3818-B has opened a new vista in the fungicidal field for the control of Rust of the *Puccinia* type. In 1958 Keil *et al.* tested various chemical compounds for the control of cereal rusts. Of these, the metal amine complexes were outstanding both as protectants and eradicants. All the successful compounds tried were consistent in having nickel as part of the molecule. Of the purely protective fungicides, the dithiocarbamates and their derivatives, e.g. zineb, showed perfect control in their protective tests. This superiority of nickel over other metallic ions in the control of infections from *P. graminis* var. *tritici* has been confirmed by Wang *et al.*, 1958. Work by Sempio as far back as 1936 using metallic ions in the nutrient solution of wheat plants would suggest that the eradicative action is due to the systemic action of the nickel ions.

The production of O-3818-B combines the virtues of the eradicative action of the nickel ion and the protective action of the dithiocarbamate so making it a far more effective fungicide than has hitherto been produced. Keil *et al.*, 1958, have shown that nickel compounds have shown eradicative as well as some protective properties under glasshouse conditions when used against rye Leaf Rust (*P. rubigo-vera*). The eradicative properties were, however, impaired after rain and the protective properties lost completely. They concluded that mixtures of nickel chloride hexa-hydrate plus dithane Z-78 was more effective as a protectant and an eradicant than the nickel salts in the presence of rain. They also showed that application of the chemicals at the "fleck" stage of the rust achieved more effective control than applications before or after this stage. Forsyth and Peturson, 1959, have confirmed these results but have also shown that high levels of nickel can be toxic to plants. Their level of toxicity was stated to 280 p.p.m. of nickel. It is of interest to note that some 6,600 p.p.m. of nickel were used in the aerial spraying trial described without any marked symptoms of toxicity developing in the wheat plants. This discrepancy may be due to the volumes of water applied. In their pot experiments, Forsyth and Peturson used the equivalent of 878 gallons of fungicide per acre whereas in the field trial only two gallons of fungicide per acre were used. It may well be that the toxicity levels for nickel will depend on the volume of water applied and the rate of entry of nickel into the plants. Information on this point would be most valuable. Glasshouse testing at rates nearer to those which have to be used in practice would also be of greater practical value to the worker in the field.

Peturson *et al.*, 1958, have shown that control of Leaf Rust similar to that achieved under glasshouse conditions can be obtained in the field. Application rates of 2 lb. and 4 lb. of the materials (of O-3818-B type) in 55 gallons of water at intervals, commencing at the heading stage, significantly reduced the incidence of Leaf Rust. Unfortunately the early frosts prevented yields being taken from their trials.

That highly efficient fungicides for the control of Stem and Leaf Rust under glasshouse conditions have been produced cannot now be doubted. It now remains to be seen whether such results can be obtained economically in the field. The eradicative properties exhibited by nickel, presumably through its direct effect on the fungus, offer a completely new method of control which is not altogether fully understood. The work of Sempio, 1936, requires further investigation in this connexion.

That nickel can be taken up in large quantities from the soil and from nutrient solutions has been clearly shown by Hunter and Vergnano, 1952, and Crooke and Knight, 1955. The latter state that Ni is more mobile in the plant than is Fe, is taken up by the plant at a greater rate in the early stages of growth and is more concentrated in the grain than in leaves and in leaves than stems. Reilhes, 1944, has also shown that Ni ions can be taken up by roots of plants from solutions of nickel salts. He showed that in very dilute solutions the Ni ions entered the vacuole fluid but were not found in the cytoplasm. If the solutions were sufficiently concentrated to damage the cytoplasm, the metallic ions were not found to penetrate the cell but were found to accumulate in the cell walls.

Mitchell, 1945, has studied the Ni content of various soil types in Scotland and has demonstrated that great differences do exist between them. Plants grown on such soils invariably contained contents of Ni which were related to the soil values. In this connexion it is interesting to note that some farmers in Kenya believe that wheat grown on some soils —notably the "black-cotton" soils—are less prone to rust than wheat grown on the red or grey soils. Although the Ni content of Kenya soils do not show the very great range exhibited by those in Scotland, Chamberlain, 1959, has shown variations from 0.32 to 2.5 p.p.m. in samples from the Kenya Highlands.

From the work outlined above three points emerge: firstly, nickel can be taken up by plants from the soil and dilute nutrient solutions; secondly, that a definite relationship exists between the amount of nickel in the soil or nutrient solution and that in the plant; and thirdly, that following uptake nickel is mobile within the plant system and accumulates within the tissues in a definite pattern.

The work of Sempio, 1956, has shown that *P. graminis* var. *tritici* can be controlled by uptake of Ni ions from a nutrient solution. The present paper has demonstrated that a reduced rust attack and an increase in the yield of wheat have been associated with an increased nickel content of the grain. Critical work to establish the relationship between nickel content of the plant, severity of rust attack and yield of grain resulting from applications of nickel salts to the soil or the leaves is urgently required. If a positive relationship exists then the problem of rust control by chemical means would be resolved into the problem of getting nickel into the plant in concentrations necessary for efficient rust control. The American workers have shown that various rusts require different concentrations of nickel applied as a spray for effective rust control (Forsyth and Peturson, 1958). This, however, may not be due to a variation in the susceptibility of the fungus to nickel, but rather a function of the site of attack; e.g. Leaf Rust requires a lower concentration of Ni ions than does Stem Rust for efficient control. The work of Hunter and Vergnano, 1954, and Crooke and Knight, 1955, show that concentration of Ni in the leaves is always higher than that in the stems. Assuming a critical concentration of Ni is required at the site of infection for efficient control, it is clear that this level would always be reached earlier in the leaves than in the stems. The concentration in the stems would only reach this critical level if the concentration of Ni in the soil or spray enabled further uptake to occur. With regard to uptake from solutions of nickel sprayed on the leaves, an optimum level may be reached after which a reduced uptake occurs. This appears to have happened in the aerial spraying trial where high concentrations of nickel were applied in low volumes of water. This may be due to the rapid drying of the spray on the leaves. Reduced uptake of Cu by apple trees at 20 p.p.m. Cu compared to that at 10 p.p.m. Cu in the spray have been noted by Arman and Wain, 1960.

Factors other than Ni content of the soil or spray can effect uptake of Ni ions. Crooke and Knight, 1955 (*b*), cite pH and Fe concentration of the soils and age of the plant as factors that can materially affect uptake. Hudson, 1956, noticed an increased heavy metal concentration—particularly nickel—in diseased hop plants attacked by the Nettlehead virus. He suggested that the high nickel content predisposed hop plants to the virus attack. Later work by Legg and Ormerod, 1957, has shown that this is not the case. They concluded that the heavy metal content of the diseased plants was a symptom rather than a predisposing factor. It is tempting to suggest that this preferential uptake of nickel by diseased plants may be the reason for the superiority of nickel sprays applied at the "fleck" stage for the control of rye Leaf Rust reported by Keil *et al.*, 1958, applications before or after this stage being less effective.

The practical outcome of the work with nickel could well result in an entirely new approach to the control of rusts of the *Puccinia* type by the utilization of seed dressings containing nickel in formulations that would render the nickel available to the plant over a long period of time. Alternatively the nickel could be combined with pelleted fertilizer for drilling with the seed. It is appreciated that nickel in high concentrations is toxic to both plants and animals and of course man, and hence some dangers are associated with its use. Such dangers are, however, not confined to nickel since a wide range of toxic seed dressings, fungicides and insecticides are in regular use by the farmer. The toxicity factor should not, therefore, be an insuperable barrier to what might well be a revolutionary method of rust control.

SUMMARY

The low average yield of 4.7 bags of wheat per acre in Kenya can be chiefly attributed to the annual incidence of Black Stem Rust (*Puccinia graminis* var. *tritici*). Average yields over the last 11 years indicate that no increases in yields have occurred in spite of agricultural extension work and plant breeding coupled with the introduction of new varieties. The reasons for this are discussed and a plea for more detailed study of the chemical methods of control made.

Two aerial spraying trials for the control of Black Stem Rust using zineb and O-3818-B (a mixture of the nickel and zinc salts of ethylene dithiocarbamate) are described. Yield increases varying from 13 per cent to 344 per cent, depending on the variety used and the number of fungicidal sprays, were obtained by the use of zineb. Such increases were invariably associated with a higher grade.

A highly significant reduction of 34 per cent in the number of pustules per plant was obtained after two sprays of O-3818-B. A corresponding increase of 7 per cent in the grain yields of Florence Aurore wheat after three such sprays was also recorded. Spraying with O-3818-B increased the bushel weight of the grain and significantly increased the thousand

grain weight. Spraying also increased the nickel content of the grain by 129 per cent above that of the controls. No marked toxicity symptoms were noticed although the concentration of nickel in the spray was 6,600 p.p.m. Secondary infection of the heads with *Cladosporium* spp. prior to harvest was inhibited on the plots sprayed with O-3818-B. Recent work on the chemical control of cereal rusts is discussed in the context of the two trials reported on.

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A TABLE OF ESTIMATES OF NUTRITIVE VALUES OF PIG FEEDS

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Glover and Dougall [1] have recently shown how average estimates of the nutritive value of feeds for pigs can be obtained from knowledge of the crude protein (CP) and crude fibre (CF) contained in the dry matter of feeds. These values are expressed in terms of digestible crude protein (DCP) and total digestible nutrients (TDN). The estimates of DCP and TDN corresponding to levels of crude protein between 2 per cent and 30 per cent and of crude fibre between 0 and 15 per cent of the dry matter are given in the accompanying Table 1.

It is not considered necessary to show the nutritive values that occur beyond an upper limit of 15 per cent crude fibre in the dry matter of the feed as a whole, since it is well known that pigs cope best with low fibre diets.

able I.—Estimates of Percentage DCP and TDN from Percentage CP and CF of the Dry Matter of the Feed

%CF	0		5		10		15	
%CP	dcp	tdn	dcp	tdn	dcp	tdn	dcp	tdn
2	0·8	44	0·7	38	0·6	32	0·5	26
3	1·4	51	1·3	47	1·1	40	1·0	37
4	2·2	59	2·0	53	1·8	48	1·6	42
5	3·0	64	2·7	58	2·5	53	2·2	47
6	3·9	68	3·5	63	3·2	57	2·9	51
7	4·7	71	4·4	66	4·0	60	3·6	54
8	5·7	75	5·3	69	4·8	64	4·4	58
9	6·6	77	6·1	71	5·7	67	5·2	61
10	7·6	80	7·1	75	6·5	69	6·0	63
11	8·6	83	8·0	77	7·4	71	6·9	66
12	9·6	85	9·0	79	8·4	74	7·7	68
13	10·7	87	10·0	82	9·3	76	8·6	70
14	11·7	89	11·0	84	10·2	78	9·5	72
15	12·8	91	12·0	86	11·2	80	10·4	74
16	13·9	93	13·0	88	12·2	82	11·3	76
20	18·4	101	17·3	95	16·3	89	15·2	84
24	23·1	108	21·8	102	20·5	96	19·3	90
30	30·0	118	28·8	112	27·2	106	25·6	100

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AVERAGE NUTRITIVE VALUES OF KENYA FEEDING STUFFS FOR PIGS

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Glover and Dougall [1] give a Table of average estimates of the percentage of digestible crude protein (DCP) and total digestible nutrients (TDN) to be expected from pig feeds ranging in crude protein (CP) content from 0-30 per cent of the dry matter and in crude fibre (CF) content from 0-15 per cent of the dry matter. This Table has been used to obtain estimates of the nutritive value of feeds actually grown or processed in Kenya and analysed in this laboratory. Descriptions of the individual feeds and estimates of their nutritive value for pigs, expressed in terms of dry matter (DM), are given in the accompanying Table 1. The actual amount of dry matter contained in most of the succulents, two of the milk products and the sugar cane molasses is reported alongside the description of these feeds. Similarly where the oil content of a feed exceeds 10 per cent of the dry matter, the actual amount of oil contained in its dry matter is reported alongside the description of the feed, e.g. coconut meal (41.5 per cent oil). Different factors have been used to convert per cent nitrogen to per cent crude protein depending on the description of the feed. The factors were selected from those described by Bolton [2]. Definitions of the terms used in the table can be found in Morrison's book [3] or Evans' bulletin [4]: gross digestible energy (GDE) is the energy contained in the total digestible nutrients.

For the growth and fattening of bacon pigs it is customary to use more than one feeding-stuff in the diet and rations vary from simple to complex mixtures. The ration "as a whole" [5] however, is designed to contain a known amount of crude protein and a minimum of crude fibre in its dry matter. For pigs within the range of 40-120 lb. liveweight it may contain some 16-17 per cent of crude protein and about 5 per cent of crude fibre in its dry matter, and for pigs of 120-220 lb. liveweight it may contain some 12-14 per cent of crude protein and about 5 per cent of crude fibre in its dry matter. Examples of simple and complex rations supplying these amounts of crude protein and relatively very low amounts of crude fibre are given as follows; the composition of the individual feeds composing the rations being taken from Table I.

Example of a Simple Mixture

Assuming an adequate supply of maize, barley and skim milk, the composition of these feeds is as follows:—

Composition	Per cent of dry matter	
	CP	CF
Maize ..	10·2	1·7
Barley ..	11·7	5·6
Skim milk ..	36·2	0

If the cereal part of the ration is composed of 60 per cent maize and 40 per cent barley, then:

	CP	CF
60 lb. Maize contain ..	6·1	1·0
40 lb. barley contain ..	4·7	2·2
100 lb. cereal mixture contain	10·8	3·2
1 lb. cereal mixture contain	0·108	0·032

and, since 100 lb. of the dry matter of skim milk contain 36.2 CP 1 lb. of the dry matter of skim milk contains 0.362 lb. CP. If the bacon pig is eight weeks old and weighs 40 lb., it will probably have an appetite of some 1.4 lb. dry matter daily and this will be composed as follows:—

Mixture	CP	CF
1 lb. dry matter from the cereal mixture	0·108	0·032
0·4 lb. dry matter from the skim milk	0·145	0
1·4 lb. dry matter of the feed as a whole contains ..	0·253	0·032
so 100 lb. dry matter of the feed as a whole contains	18·06	2·29

From the Glover and Dougall Table [1] it is seen that a feed containing 18 per cent CP and 2.3 per cent CF in its dry matter, also contains 15.8 per cent DCP and 95 per cent TDN so 100 lb. of the dry matter of the feed contains 15.8 lb. DCP and 95.0 TDN; 1.4 lb. of the dry matter of the feed contains 0.221 lb. DCP and 1.33 lb. TDN. Our sample of skim milk contains 8.8 per cent dry matter, so 8.8 lb. dry matter are contained in 100 lb. liquid skim milk; 1 lb. dry matter is contained in 11.36 lb. liquid skim milk; 0.4 lb. dry matter is contained in 4.5 lb. liquid skim milk.

Since it is liquid skim milk that is fed, the diet for this small pig becomes 1 lb. dry matter from the cereal mixture composed of 60 per cent maize and 40 per cent barley, together with 4½ lb. of skim milk. Table II (*a*) gives further details of the quantities of food and nutriments consumed by this animal as it grows to the required weight on this diet. It is noteworthy that if buttermilk could always approximate to the same composition as given in Table I, its value as an alternative to skim milk is assured.

Example of a Complex Mixture

The diet of the bacon pig is to be as follows:—

RATION A		RATION B	
For pigs from 40–120 lb. liveweight		For pigs from 121–220 lb. liveweight	
	%		%
Maize	60	Maize	60
Barley	24	Barley	28
Protein concentrate	16	Protein concentrate	12

and the protein concentrate is constituted as follows:—

Per cent Composition	Per cent of Dry Matter		Weight	In the Dry Matter	
	CP	CF		CP	CF
Cottonseed cake ..	39·3	13·7	20 lb. contain	7·86	2·74
Groundnut cake ..	37·2	12·5	20 lb. contain	7·44	2·50
Liver meal	67·1	0·7	2·5 lb. contain	1·68	0·02
Blood meal	80·5	1·8	14 lb. contain	11·27	0·25
Carcass meal	60·6	3·2	33·5 lb. contain	20·30	1·07
Minerals	0	0	10 lb. contain	0	0
			100 lb. contain	48·55	6·58

Ration A now becomes:—

Per cent Composition	Per cent Dry Matter of		Weight	In the Dry Matter	
	CP	CF		CP	CF
Maize	10·2	1·7	60 lb. contain	6·1	1·0
Barley	11·7	5·6	24 lb. contain	2·8	1·3
Protein concentrate ..	48·55	6·6	16 lb. contain	7·8	1·1
			100 lb. contain	16·7	3·4

From the Glover and Dougall Table [1] it is seen that a feed containing 16.7 per cent CP and 3.4 per cent CF in its dry matter also contains 14.1 per cent DCP and 91.6 per cent TDN, so 100 lb. Ration A contains 14.1 lb. DCP and 91.6 lb. TDN, or 1 lb Ration A contains 0.141 lb. DCP and 0.916 lb. TDN.

By similar reasoning 100 lb. Ration B, composed of 60 lb. maize, 28 lb. barley and 12 lb. of the protein concentrate contains 15.2 per cent CP and 3.4 per cent CF on a dry matter basis, and reference to the Glover and Dougall Table [1] shows that this feed contains 12.5 per cent DCP and 87.5 per cent TDN, so 100 lb. Ration B contains 12.5 lb. DCP and 87.5 lb. TDN; 1 lb. Ration B contains 0.125 lb. DCP and 0.875 lb. TDN. Table II (*b*) gives details of the quantities of food and nutriments consumed by this animal as it grows to the required weight on these diets.

There is no suggestion that any of the diets so described are beyond improvement so practical notes about the components of the diets are given in the succeeding paper of this number [6].

It is not the purpose of this paper to discuss in detail minerals in relation to pig rations. None the less it is important to appreciate that if the required amounts of elements such as calcium, phosphorus, chlorine, etc., cannot be obtained from the individual components of rations in amounts that are adequate for growth and development, a supplementary source must be provided. This may take the form of a mixture of finely divided agricultural lime, sodium chloride, etc., in pre-determined proportions and fed as a fixed percentage of the concentrate ration.

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TABLE I.—AVERAGE NUTRITIVE VALUES OF KENYA FEEDING STUFFS FOR PIGS

(*Per cent of dry matter*)

Description	Crude Protein CP	Digestible Crude Protein DCP	Nutritive Ratio NR	Total Digestible Nutrients TDN	Gross Digestible Energy GDE	Crude Fibre CF	Calcium Ca	Phosphorus P
CEREAL GRAINS AND CEREAL PRODUCTS								
Barley grain	11·7	8·6	8·1	79	82	5·5	0·05	0·30
Barley meal, coarsely ground	11·9	9·2	7·9	82	86	2·5	0·03	0·27
Barley meal, finely ground	12·2	9·3	7·8	82	86	3·7	0·07	0·33
Maize grain	10·2	7·6	9·3	79	82	1·7	0·05	0·29
Maize bran	6·3	2·9	15·9	48	49	18·9	0·02	0·21
Maize meal, white	8·6	6·1	11·2	74	77	1·9	0·03	0·19
Maize meal, yellow	9·2	6·6	10·5	76	79	1·9	0·04	0·18
Millet grain	13·1	10·6	7·1	85	89	1·5	0·05	0·24
Millet bran	20·2	17·7	4·5	97	104	4·4	0·05	0·47
Oat grain	9·9	6·6	9·6	69	72	8·8	0·11	0·32
Pollards	16·7	13·2	5·5	86	91	8·4	0·14	0·96
Rice grain, commercial	8·5	6·1	11·5	76	79	0·2	0·03	0·12
Rice paddy	10·5	7·1	9·1	71	74	9·4	0·06	0·22
Rice bran	9·7	5·0	9·8	54	56	22·5	0·16	0·58
Rice dust	2·1	nd	nd	nd	nd	39·8	0·10	0·12
Rye grain	15·5	12·7	5·9	87	92	4·1	nd	nd
Sorghum grain, red	11·8	9·1	7·9	82	85	2·2	0·08	0·39
Sorghum grain, white	12·8	10·2	7·2	84	88	1·6	0·10	0·30
Sorghum bran, red	11·7	8·6	8·1	78	82	5·9	0·14	0·67
Sorghum bran, white	12·6	8·8	7·4	74	78	10·8	0·17	1·18
Wheat grain	14·2	11·6	6·5	86	91	2·5	0·05	0·45
Wheat bran	13·8	9·5	6·8	73	77	14·0	0·18	1·13
LEGUME SEEDS AND OIL SEEDS								
Chick pea (*Cicer arietinum*)	22·9	19·1	3·9	94	101	10·9	0·16	0·43
Cowpea (*Vigna sinensis*)	26·9	24·5	3·2	103	113	7·1	0·17	0·44
Horse gram (*Dolichos biflorus*) (10·4% oil)	30·6	27·7	2·8	105	116	10·5	0·12	0·36
Lentil (*lens esculenta*)	29·6	28·7	3·0	115	126	3·9	0·06	0·28
Lima bean (*Phaseolus lunatus*)	21·8	19·1	4·1	98	105	5·9	0·12	0·39
Njahi = hyacinth bean (*Dolichos lablab*)	27·7	23·4	3·2	98	108	14·1	0·10	0·40
Pea, field or garden (*Pisum sativum*)	24·2	21·6	3·6	99	108	6·7	0·09	0·40
Pigeon pea (*Cajanus cajan = indicus*)	24·6	21·3	3·5	96	105	9·4	0·22	0·30
Safflower seed (*Carthamus tinctorius*) (23% oil)	14·4	7·1	6·5	54	57	32·8	0·16	0·49
Soya bean (*Glycine max.*), var. Bukoba (11·2% oil)	43·8	nd	nd	nd	nd	5·1	0·23	0·70
Sweet white lupin (*lupinus albus*) (14·3% oil)	30·8	27·6	2·8	105	116	11·6	0·28	0·37
Sweet blue lupin (*lupinus angustifolius*)	36·1	32·9	2·3	108	122	13·7	0·14	0·36
Sweet yellow lupin (*lupinus luteus*)	40·9	37·8	2·0	114	129	15·0	0·15	0·47
Sword bean (*Canavalia ensiformis*)	30·4	27·9	2·8	106	117	9·4	0·19	0·25
Velvet bean (*Stizolobium deeringianum*)	29·7	27·1	2·9	106	117	9·2	0·12	0·30
CONCENTRATES—PLANT								
Banana flour	6·1	3·9	16·2	66	68	1·2	0·01	0·12
Cassava, dried	2·0	0·7	55·0	41	41	2·2	0·16	0·07
Coconut meal (41·5% oil)	27·4	26·1	3·2	108	119	3·8	1·36	0·70
Copra cake	24·2	20·7	3·6	96	104	10·1	0·23	0·57

TABLE I.—AVERAGE NUTRITIVE VALUES OF KENYA FEEDING STUFFS FOR PIGS—(*Contd.*)
(*Per cent of dry matter*)

Description	Crude Protein CP	Digestible Crude Protein DCP	Nutritive Ratio NR	Total Digestible Nutrients TDN	Gross Digestible Energy GDE	Crude Fibre CF	Calcium Ca	Phosphorus P
Cottonseed cake, decorticated ..	39·3	36·5	2·1	115	129	13·7	0·27	0·82
Cottonseed cake, de-linted	24·1	16·6	3·6	77	83	25·7	0·26	0·72
Groundnut cake	37·2	34·6	2·3	114	128	12·5	0·59	0·80
Linseed cake	29·9	26·4	2·9	103	113	12·3	nd	nd
Sweet potato flour	4·8	2·7	21·4	60	61	3·3	0·21	0·69
CONCENTRATES—ANIMAL AND FISH								
Bone meal	26·5	nd	nd	nd	nd	nd	26·91	11·55
Blood meal	80·5	,,	,,	,,	,,	1·8	0·41	0·23
Carcass meal	60·6	,,	,,	,,	,,	3·2	9·62	3·51
Fish meal from lake fish	49·4	,,	,,	,,	,,	nd	15·80	5·90
Liver meal	67·1	,,	,,	,,	,,	0·7	1·63	1·60
Meat meal (10·7% oil)	54·2	,,	,,	,,	,,	nd	12·87	5·62
MILK PRODUCTS								
Buttermilk (7·5% dry matter) ..	34·0	34·0	2·5	119	133	0	nd	nd
Rennet whey	17·0	15·0	5·4	95	101	0	0·54	0·36
Skim milk (8·8% dry matter) ..	36·2	36·2	2·3	119	133	0	nd	nd
Skim milk powder	33·2	33·2	2·6	118	132	0	1·36	0·79
BY-PRODUCTS								
Brewer's grain	19·5	14·9	4·6	83	89	14·1	0·18	0·38
Sugar cane molasses (73·7% dry matter)	3·4	1·7	30·9	56	57	0	1·13	0·04
SUCCULENTS								
Canna leaves from field crop (15% dry matter)	8·7	4·6	11·2	57	58	18·5	1·15	0·16
Canna roots from field crop (29% dry matter)	1·8	0·6	61·7	38	38	3·2	0·03	0·16
Fodder beet, var. Otofte Red (22% dry matter)	8·7	5·6	11·2	69	71	7·5	nd	nd
Fodder beet, var. Hunsballe (22% dry matter)	9·5	6·4	10·0	70	72	7·5	,,	,,
Fodder beet, var. Pajberg Rex (26% dry matter)	9·3	6·2	10·2	69	72	7·5	,,	,,
Kale, Thousandhead (16% dry matter)	17·5	11·8	5·3	74	79	20·0	,,	,,
Kohl Rabi (13% dry matter) ..	17·5	13·4	5·2	83	88	11·7	,,	,,
Lucerne, 12–18 inches high (25% dry matter)	24·4	17·3	3·6	80	87	24·1	1·20	0·38
Mangolds, yellow fleshed globe or tankard (12% dry matter)	11·7	8·7	8·1	79	82	5·3	nd	nd
Rape, dwarf (14% dry matter) ..	27·4	23·3	3·2	98	107	13·2	1·83	0·33
Rape, giant	20·5	16·1	4·4	87	93	13·4	1·36	0·20
Rape, broad leaf	24·2	20·3	3·6	94	102	11·7	1·44	0·21
Sweet potato tops	18·1	16·0	5·0	96	103	10·7	0·83	0·15

TABLE II (*a*) AND (*b*) SHOWING THE DCP AND TDN CONSUMED BY THE BACON PIG DURING GROWTH TO 220 LB. LIVEWEIGHT ON A SIMPLE AND A COMPLEX RATION RESPECTIVELY

	TABLE II (*a*)—SIMPLE RATION								TABLE II (*b*)—COMPLEX RATION				
Liveweight (lb.)	DM intake from cereals (lb.)	Intake from skim milk (lb.) liquid	Intake from skim milk (lb.) DM	Total DM intake (lb.)	Composition of ration "as a whole" (% DM) CP	Composition of ration "as a whole" (% DM) CF	DM intake (lb.) DCP	DM intake (lb.) TDN	Total DM intake (lb.)	Composition of ration "as a whole" (% DM) CP	Composition of ration "as a whole" (% DM) CF	DM intake (lb.) DCP	DM intake (lb.) TDN
to 40	1·0	4·5	0·40	1·40	18·1	2·3	0·221	1·33	1·40	16·7	3·4	0·197	1·28
51–60	1·4	5·1	0·45	1·85	17·0	2·4	0·268	1·72	1·85	,,	,,	0·261	1·69
71–80	1·8	6·2	0·55	2·35	16·7	2·5	0·336	2·18	2·35	,,	,,	0·331	2·15
91–100	2·2	7·4	0·65	2·85	16·6	2·5	0·402	2·62	2·85	,,	,,	0·402	2·61
111–120	2·6	8·5	0·75	3·35	16·5	2·5	0·469	3·05	3·35	,,	,,	0·472	3·07
141–150	3·2	8·5	0·75	3·95	15·6	2·6	0·514	3·56	3·95	15·2	3·4	0·494	3·46
161–170	3·6	8·5	0·75	4·35	15·2	2·7	0·548	3·83	4·35	,,	,,	0·544	3·81
171–180	3·8	8·5	0·75	4·55*	15·0	2·7	0·564*	4·05*	4·55*	,,	,,	0·569*	3·98*

*The intake of DM, DCP and TDN remains at these levels until the animal reaches 220 lb. liveweight.

NOTES ON THE UTILITY OF KENYA FEEDING STUFFS CONSIDERED SUITABLE FOR PIGS

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The notes that follow are not in any way meant to be complete, for this is not a minor treatise on pig feeding. They are simply meant to be read in conjunction with Table I of Dr. Dougall's paper and as a guide to the practical farmer who may be using Dr. Dougall's table of nutrient values. Notes on separate feeds are arranged in the same sequence as in Dr. Dougall's table.

CEREAL GRAINS AND CEREAL PRODUCTS

Barley

Barley should not be fed to pigs as a whole grain but should be ground to a meal (medium grind). It is slightly less palatable than maize and possesses 90 per cent of it's feeding value, but it is an outstandingly good cereal for pig production and can be used as the only cereal in a ration. It produces pork and bacon of high quality, with a hard, white fat.

Maize

Of all cereals maize is richest in carbohydrates. It should not be fed as the sole component of the cereal part of the ration as its protein is deficient in certain essential amino-acids. It is certainly safe to use it at the rate of 40 per cent of the total ration and higher levels may be fed, but when it is included in the ration at very high rates there is a definite danger that it will produce pigs with soft fat. When fed at too high an inclusion rate it is also said to produce a "taint" in the bacon.

Maize should be coarsely ground or crushed for fattening pigs otherwise some of its feeding value is wasted. Yellow maize is usually slightly superior in protein content to white maize and also contains some carotene, the precursor of vitamin A. Maize bran should be used in the same way as wheat bran, though it has a slightly lower feeding value.

Millet

Millet as a carbohydrate feed has approximately the same value as maize, though it is superior in protein content. When fed as the only cereal in the ration it produces pork or bacon of inferior quality. Millet should be mixed with other cereals and should never exceed 30-35 per cent of the total cereal ration. It should be crushed or ground before feeding. Millet bran is superior in feeding value to wheat or maize bran but should be used in approximately the same way.

Oats

Oats are not widely used as a pig feed because of the high percentage of husk in the grain. They possess about 75 to 85 per cent of the feeding value of maize. It is generally recommended that their use should be limited to 25 to 30 per cent of the ration of young fattening pigs. They can be used to replace half the cereals in the ration of sows during gestation, but two to three weeks before farrowing the percentage of oats in the cereal ration should be reduced to 25 or 30 or the milk supply of the sows may suffer. When oats form too high a proportion of the ration there is a danger of producing pigs with soft fat, and in the case of young pigs, scouring and other digestive disturbances. The feeding value of oats is increased by 20 to 25 per cent by grinding (fine to medium grade), though they can also be crushed or rolled before feeding.

Rice

Rice grain is not likely to be used as a pig feed. Paddy has about 85 per cent of the feeding value of maize. It is not a very satisfactory grain feed and should never be used as the sole cereal in the diet as it will produce soft fat. Fed at the rate of 25 to 30 per cent of the ration it is quite satisfactory. It should be ground (medium) before use. Rice bran has a high fibre and fat content. It often goes rancid during storage because of its high fat content. It should not be fed to very young pigs as it slows down growth and may cause scouring. It can be fed to older pigs, and particularly to breeding sows and gilts but it should never exceed 10 to 20 per cent of the total ration even in the case of breeding pigs.

Rice dust as produced in East Africa is not a suitable feed for pigs. If used it should be in very small quantities and then only for breeding pigs.

Rye

Rye is not so palatable as most of the other cereal grains. It has 90 per cent of the feeding value of maize. Normally it should not exceed 10-20 per cent of the total ration. It is frequently contaminated with a fungus called ergot. This makes rye even more unpalatable, and may cause abortion or lactation failure in the sow, or scouring in the young pig.

Sorghum

This grain has a feeding value approximately 90 per cent that of maize. When fed as the sole component of the cereal part of the ration it produces soft fat, though pigs fatten well on it. It should not be used at the rate of more than 50 per cent of the cereal ration. It should be ground before feeding (medium). Different varieties of sorghum exhibit varying degrees of palatability. This is due to differences in the amounts of tannin in the grain.

Wheat

Wheat is an excellent feed for pigs and can be fed alone or with other grains. Its feeding value is slightly superior to maize. It should not be fed whole, or ground too finely, as it is inclined to become doughy when moist and easily "cakes". It should either be coarsely ground or crushed. It produces good quality pigs.

Bran should not be fed at high levels. Five per cent is the recommended level for fattening pigs but it may be used at the 10-20 per cent level in the ration of sows. When fed wet it has a laxative action.

Pollards is a very suitable feed for young pigs but should not constitute too high a proportion of the grain part of the ration as when fed alone it will produce a soft fat. It is usually fed to fattening pigs at up to 20 per cent of the cereal ration.

LEGUME AND OIL SEEDS

Peas of various types can be used mixed with cereals at the rate of 25 to 30 per cent of the ration. When fed alone they produce a very hard, lean, flesh. Young pigs do not thrive on a diet solely consisting of peas. They are particularly valuable when mixed with wheat or barley. It is essential to feed a mineral mixture high in calcium and phosphorus when feeding peas. From a quality point of view, cowpeas are one of the best peas to use.

Beans are better fed cooked although they can be used raw with other cereals. The protein of most beans is not of good quality and they should never form more than 15 per cent of the total ration. As a sole feed they produce inferior pork and bacon.

Safflower Seed

This seed has 40 per cent or more of hulls and is not satisfactory as a feed for fattening pigs. It can, however, be fed in small amounts to breeding pigs.

Soya Bean

Although soya bean meal is an excellent protein concentrate, the feeding of soya beans should be limited to about 10 per cent of the ration. Otherwise there is a danger of producing a pig with a soft fat. Soya beans should not be used at all in the ration of older fatteners. They are best fed cooked and need a mineral supplement with a high calcium and phosphorus content.

Lupins

The seed of most varieties is poisonous to animals because it contains toxic alkaloids. Seed of the yellow and blue varieties is least poisonous and experiments in the U.K. have shown that a ration containing 10 per cent of the seed of the yellow variety, can be fed with safety.

Velvet Bean

This bean, apart from possessing a protein of poor quality, contains dihydroxyphenylalanine, a substance related to adrenalin, that is toxic to pigs, causing diarrhoea and vomiting. These beans should only be fed at a very low level to any class of pig, and pigs should not be turned into velvet bean pastures.

PLANT CONCENTRATES

Banana Flour

This feed is unlikely to be freely available. Waste green bananas can, however, be fed to pigs.

Cassava

Dried cassava has a feeding value, on a carbohydrate basis, equal to maize, though it has a lower protein content. It produces a firm, hard, white fat and is an excellent feed, though it is better fed with barley than with maize. It can replace up to 60 to 70 per cent of cereal in the ration but is better restricted to up to 25 per cent of the total ration. When feeding large amounts of dried cassava slightly more protein supplement should be used than when cereals are fed. Fresh cassava roots can be fed to pigs, though care must be taken in doing so, as some varieties contains poisonous substances mainly found in the skin. Cooking fresh cassava obviates these difficulties.

Coconut Meal

Should only be used in small quantities and never in the rations of pigs that are being "finished" as it produces a "soft fat". This meal easily becomes rancid during storage. It has a high capacity for absorbing molasses and can be used for this purpose when molasses is available in quantity.

Copra Meal

This is a very palatable meal and can be used as part of the protein supplement. It should not be fed at too high an inclusion rate.

Cottonseed Cake

Only the high protein content cake is really suitable for pig feeding. The cake with a crude protein content of 24 per cent and a crude fibre content of 25.7 per cent should not be used.

The protein in cottonseed cake is deficient in certain essential amino-acids and it should not be used as the sole protein concentrate, though it can be included up to the rate of 40 per cent in a mixed protein supplement. It helps produce a pig with a hard fat.

Another reason for not using cottonseed cake at too high an inclusion rate is that it contains a toxic substance known as gossypol. Included at the rate of 7 to 10 per cent in the final ration it does no harm to older pigs, but even these inclusion rates are suspect for young pigs.

Groundnut Cake

This is a very palatable feed, but because of its relatively high oil content it tends to go rancid rather quickly. It should not be stored for more than six weeks in a hot climate. It should be used at about the same inclusion rates as cottonseed cake. It is not suitable as a sole protein supplement to cereals, though the quality of its protein is good; as it causes a soft fat and sometimes a distinctive flavour in the bacon.

Linseed Cake

It is more satisfactory to use this protein feed with wheat and barley rather than maize, millet or sorghum. It should never form more than 5 to 25 per cent of the protein supplement and in the case of young pigs never more than 5 per cent. It has a slight laxative effect.

Sweet Potato Flour

This flour has about 90 per cent of the feeding value of maize, it can be used to replace up to 25 per cent of the cereals in the ration. The raw roots can also be fed, though cooking improves their value as a feed. They replace cereals at the rate of about 4 lb. of sweet potatoes to 1 lb. of cereal. They tend to produce a hard pork or bacon.

ANIMAL AND FISH CONCENTRATES

Bone Meal

Of use in the mineral part of a pig's ration.

Blood Meal

This is a very unpalatable protein feed and must not be fed as the sole protein supplement as it is also deficient in certain essential amino-acids. It should be used as part of a mixed protein supplement and is particularly valuable when fed together with carcass meal or meat and bone meal.

Carcass Meal

This is a more valuable protein feed than meat, or meat and bone meal as it also contains blood meal. It should not be used as the sole protein supplement but as part of a mixture, unless it is sold as a balanced protein mixture.

Fish Meal (Lake Fish)

Fish meal is usually regarded as superior to meat meal as a protein supplement but the East African fish meal is definitely not as good as the white fish meal used in the U.K. It can be used at the rate of 5 to 30 per cent in the protein supplement but should not be used during the last few weeks of fattening in case it imparts a fishy flavour to the pork or bacon.

Liver Meal

This meal is an excellent source of the vitamin B complex and also apparently contains certain unidentified factors that are useful in pig nutrition. It should be included at a low level (2 to 3 per cent) in protein supplements.

Meat Meal

There are various grades of meat, and meat and bone meal. Meat meal is superior as a protein supplement to meat and bone meal.

It should not be fed as a sole protein supplement as it is deficient in certain essential amino-acids but can provide up to 50 to 60 per cent of the meal in a protein supplement.

MILK PRODUCTS

Buttermilk

Buttermilk is slightly inferior to skim milk in feeding quality and should be used in the same manner.

Rennet Whey

It can be fed fresh or sour. It should not be considered as a protein supplement but as a substitute for part of the cereal ration. It contains 65-70 per cent lactose, the most suitable carbohydrate feed for the baby pig and is an excellent source of B vitamins. Care must be taken in the feeding of rennet whey otherwise it will produce pot-bellied pigs of indifferent quality. It should not be fed in excessive amounts.

Skim-milk

Skim-milk is a very useful protein feed. When fed as the sole protein supplement it is best used with a cereal ration consisting mainly of barley, though in New Zealand it is fed with pollards. It is usual to feed a fixed volume daily. From four to six pints daily per animal appears to be a very suitable ration. It can be fed fresh or sour, but it should not be fed fresh and/or sour, on alternate days. If supplies are limited it should be fed to the baby piglets and/or lactating sows or gilts.

Dried skim-milk is usually too expensive to use as a pig feed but if it is cheap enough it is a very good protein concentrate to include in the ration of baby pigs.

BY-PRODUCTS

Brewers' Grain

The wet grain contains 70 to 75 per cent water so that it is not economic to transport it over long distances. It is best fed to pigs weighing over 100 lb. liveweight. It is not very palatable and is best fed mixed with other more palatable feeds.

Sugar Cane Molasses

Some pigs eat molasses, others reject it. When fed to excess it causes scouring. It should not form more than 10 per cent of the ration of younger pigs and 20 per cent of the ration of older pigs though it is possible that it could be used at a higher level for the feeding of "heavy" pigs.

Used in small amounts it usually improves the palatability of other feeds.

SUCCULENTS

These are usually used simply to provide the pig with a little green feed and hence with additional minerals, vitamins, and perhaps as an appetizer. It is usual to feed about 10 lb. per head per day to fattening pigs, that do not have access to pasture.

Canna

Whole canna (leave and roots) will cause some scouring particularly in the young pigs. It is better fed mixed with other succulents. The roots of the canna when fed alone are equivalent to about 20 to 25 per cent of the feeding value of maize.

Lucerne

This is an exceptionally valuable green feed for pigs, as it appears to contain unidentified factors that are of particular value to breeding pigs. It has been suggested that if pigs do not receive any other form of green food they should get about 2.5 to 5 per cent of lucerne meal in their ration. When fed above the 10 to 15 per cent level, lucerne meal will slow down the rate of growth.

There is a fattening system known as the "Lehman" where the fattening pigs are given a basic ration of 2.2 lb. of meal per day (containing up to 30 per cent protein) and the remainder of the ration is made up with succulent roughage, such as fodder beet, kale, kholrabi, mangolds, etc. Very little is known in East Africa as to the value of this system.

Rape

One of the best annual pasture crops for pigs; nearly equal to lucerne or red clover in feeding value. It occasionally causes blistering or sun scalding.

THE INSECT PESTS OF AGRICULTURE IN THE COAST PROVINCE OF KENYA

III—SWEET POTATO

By **P. E. Wheatley, Entomologist, Department of Agriculture, Kenya**

(*Received for publication on 13th April, 1960*)

The three main pests of sweet potatoes, *Cylas, Alcidodes* and *Aegeria,* all live in the vines and tubers of the crop where they are well protected from applications of insecticides. In all cases, however, strict enforcement of cultural control measures will reduce infestation very markedly, leading to higher yields and a more palatable crop. The minor pests listed are normally of little consequence and it will only be in rare cases that the control measures given will be required.

There is evidence that certain varieties of sweet potato are more resistant to attack by *Cylas* than others. Generally speaking, the white tubered varieties are less resistant than the red tubered, and the "Mwezi Moja" variety which is commonly grown at the Coast is perhaps one of the most susceptible. Where possible, varieties with red leaf veins and red tubers should be encouraged, but account should be taken of yield potential and palatability of these.

SWEET POTATO WEEVIL (*Cylas puncticollis*)

The adults are slender, shiny black, ¼ in. long and easily mistaken for ants. The larvae are curled, wrinkled and legless, dirty white in colour.

Life History

The adults may be found either on the aerial parts of sweet potato or in the soil. Eggs are laid in minute holes drilled by the females in the tubers or vines and they hatch one week later. The larvae tunnel in the tubers and vines for about two weeks, their tunnels increasing in width as the larvae grow up to a diameter of a little under ⅛ in. Pupation then takes place inside the tuber or vine and one week later the adult weevil emerges. The complete life cycle lasts about one month.

Damage

External examination of an infested tuber reveals a number of small holes which are caused by the feeding and egg-laying of the adult weevils and some larger holes where adults have emerged from the potato. On cutting the tuber open the larval tunnels will be found, and in cases of heavy infestation the whole potato will be completely riddled with them. In cases where only part of the potato has been damaged, the undamaged portion is likely to have a bitter taste when eaten. The weevil continues to breed in potatoes after harvesting, and the infestation builds up if they are stored for any length of time until eventually all tubers are inedible. In addition to damage to the tubers, infestation of the vines by larvae affects the vigour of the plant and yield is reduced.

Control

Once a crop is infested there are no means of effectively controlling this pest; control measures are aimed at preventing the initial infestation.

Care must be taken to rotate sweet potato land so that successive crops are never grown in the same field. In cases where a crop is known to be infested, sweet potatoes should if possible not be grown the following season within half a mile of the infested field, but Field Officers must use their discretion in this matter. If necessary they should advise peasant farmers not to plant sweet potatoes one year so that a heavily infested area may become decontaminated; one year without a sweet potato crop is sufficient for this purpose. Clean (uninfested) planting material only must be used. If there is doubt about this, the setts should be dusted with 10 per cent D.D.T. dust before planting. If sweet potatoes are to be stored, first dust the store with 10 per cent D.D.T. dust at 1 lb. per 1,600 sq. ft. of surface. Infested tubers should be fed to stock or destroyed.

Alcidodes orientalis AND *A. dentipes*

A. orientalis is a brown-black weevil just over ½ in. long, with an irregular white patch on each wing case. *A. dentipes* is brown, ⅜ in. long, with four white streaks running down its back.

Life History

The life history of these two weevils is similar to that of sweet potato weevil, although the life-cycle probably takes a little longer.

Damage

Damage is similar to that of sweet potato weevil, although the tunnels are larger and may reach a diameter of ¼ in. Damage to tubers continues in the store. One frequently finds that these species cut the vines of sweet potato causing the leaves to turn yellow and wither.

Control

As for sweet potato weevil.

AEGERIA SP.

The adults are clear wing moths, black and white in colour with a wing span of a little under 1 in. The larvae are whitish caterpillars each with three pairs of very small legs and five pairs of "false feet".

Life History

The full life history of this pest is not known. The adults are day-flying and lay large batches of eggs, usually 75 to 150 at a time. The eggs are probably laid on the vines and the young caterpillars when they hatch out burrow into the vines and tunnel downwards, often to the tubers. Pupation may take place in the tuber but more frequently in the main stem of the plant just above ground level, the pupa being enclosed in a brown cocoon. After the adult has emerged the pupal case can often be seen protruding from the stem of the plant.

Damage

Larval tunnelling causes a characteristic galling of the main stem at ground level, debilitating the plant and reducing yield. In addition, infestation of tubers occurs, this damage continuing in stored potatoes as is the case with sweet potato weevil and *Alcidodes* spp.

Control

No insecticidal control in the field is known, but the measures recommended for sweet potato weevil should be adhered to for these will undoubtedly help to reduce the infestation.

MINOR PESTS

Aspidomorpha parummaculata

This is a tortoise-beetle, light brown in colour and nearly ½ in. long which feeds on the foliage. For control, 20 lb. of 5 per cent D.D.T. dust may be applied per acre. Alternatively three pints of 25 per cent D.D.T. emulsion in up to 120 gallons of water per acre should be applied as a medium or high volume spray. Do not feed vines to cattle within two weeks of a D.D.T. application.

Blosyrus sp.

This brown weevil has a short broad snout and is ⅜ in. long. It feeds on the foliage of sweet potato. Control as for *Aspidomorpha.*

Brachmia convolvuli

The caterpillars of this small moth feed on the foliage and roll the leaves into tunnels in which they hide. Control as for *Aspidomorpha.*

THE EFFICIENCY OF BLOCKS IN SOME EXPERIMENTS IN KENYA

By **R. T. Clarke, Department of Agriculture, Kenya**

(*Received for publication on 25th August, 1960*)

Field Experiments in the tropics are frequently hampered by inherent variation in the experimental material greater than that met with in more temperate latitudes. Soil variation is such a factor in much of Kenya and on an experimental site a fertility trend is often small in comparison with local variability in the form of soil patches. Such variability may be caused by the presence of destroyed ant-hills and of former hut sites which cannot always be distinguished and avoided before the experiment is begun.

Because variation within blocks is frequently and uanvoidably high, the increase in efficiency resulting from their use may be small, and, in the case of factorial experiments, there may be little advantage in confounding as a means of reducing block size. Accordingly data on the efficiencies of 160 experiments carried out by the Department of Agriculture were examined, this being the number for which analyses were available. Where a randomized block experiment had been used, an estimate of the error variance of the corresponding completely randomized design was calculated from the formula:—

$$\frac{\text{blocks s.s.} + (\text{treatment d.f.} + \text{error d.f.}) \times (\text{error m.s.})}{\text{total d.f.}}$$

and this estimate is directly comparable with the error variance of the randomized block experiment. Similarly for an rxr latin square, the efficiency relative to complete randomization is:—

$$\frac{\text{rows m.s.} + \text{column m.s.} + (\text{r-l})\ \text{error m.s.}}{(\text{r-l})\ \text{error m.s.}}$$

The efficiency of the confounding in factorial experiments was also found, using the method given in Cochran and Cox (1). For example, the error variance of a 3^3 factorial in two replicates was compared with the calculated error variance of the corresponding experiment consisting of two randomized blocks of 27 plots. The efficiencies calculated were slightly over-estimated in the case of randomized blocks and latin squares; however, since this over-estimate is small, adjustments were not made.

For the confounded designs, the following results were obtained:—

Design	Number examined	Number no more efficient than unconfounded design	Average efficiency (relative to randomized blocks)
			%
3^3 (2 reps.)	52	21	114
3^3 (1 rep.)	39	15	121
2^4 and 2^5 (blocks of 8)	19	7	110

Forty-one randomized blocks were examined, of which 11 were no more efficient that a completely randomized design; the average gain in efficiency was 17 per cent. In results given by Yates (2), who examined two groups of 22 experiments, the corresponding average gains were 28 per cent and 25 per cent.

Fifteen latin squares gave an average gain in efficiency of 28 per cent relative to completely randomized designs, compared with figures of 46 per cent and 43 per cent given by Yates. These results were, however, based on more experiments—38 in 1932 and 37 in 1933.

The value of blocking may well be greater if plots of a smaller size are used, and some recent work by R. T. Ellis (3) on maize trials showed that a considerable reduction in coefficient of variation results from the use of very small plots and increased replication. Alternatively, Pearce (4) suggests that the method of Papadakis may be useful in such circumstances, but this involves the additional computation of a covariance analysis.

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EFFECTS OF LEGUMES AND FERTILIZERS ON YIELD OF TEMPORARY LEYS

By R. Strange, Grassland Research Station, Kitale, Department of Agriculture, Kenya

(*Received for publication on 7th November, 1960*)

In May, 1955, an exploratory trial was laid down on this Station, and was continued for four seasons, to gain information on the effects of legumes in pasture mixtures, in the presence and absence of fertilizer phosphorus and gypsum. Part I of the trial, which is reported separately from Part II, was continued for two complete seasons, 1955 and 1956. Towards the end of 1956 the plots were split and gypsum was applied. The growth of the pastures including the effect of the gypsum during the last two complete seasons, in 1957 and 1958, is described in Part II.

PART I

EXPERIMENTAL

The trial included four grasses: star grass (*Cynodon dactylon*); commercial molasses grass (*Melinis minutiflora*); Nzoia rhodes grass (*Chloris gayana*); and Nandi setaria (*Setaria sphacelata*), each of which was established alone; with Kenya white clover (*Trifolium semipilosum*); and with Kenya white clover and lucerne. Triple superphosphate was applied at the rate of, control (P0); 2 cwt. per acre in 1955 and 1 cwt. in 1956 (P1); and 4 cwt. per acre in 1955 (P2). The mixtures were sown in alternate rows and in these the grass components were established at the same seed rates as in pure stand. Where lucerne was also sown, however, the seed rates of the grasses were halved. The legumes were inoculated before sowing, but the effectiveness of the inoculant was doubtful, for nodulation was belated and irregular.

The trial was arranged as a randomized 3 × 3 factorial experiment having four blocks, and with species and fertility effects confounded. This design gives no valid estimate of the error mean square, being a single replicate of a split plot design. An error mean square was obtained by assuming the three factor interactions to be negligible and by combining certain two factor interactions with it.

In all tables the quantity which is given as "S.E. of differences" denotes the standard error of the difference between any two means in the body of the table. As a rough guide, any differences between means that exceed twice the quantity of the standard error may be regarded as statistically significant.

The plots were 344 sq. ft., and ten quadrat samples each of 10 sq. ft. were taken at random within each plot for yield data and herbage composition prior to grazing. Representative 3 lb. samples were taken from the cut material for estimation of dry matter and crude protein, and 100 g. samples were taken from these for hand separation into their component species. All yield figures are corrected to exclude the weed fraction.

The plots were grazed overall at intervals whenever growth was sufficient.

RESULTS

The mean annual dry matter yield of the four mixtures was:—

	(cwt per acre)				
	Star	Molasses	Setaria	Rhodes	Mean
1955	34·6	58·2	35·5	33·9	40·5
1956	21·2	40·0	25·7	25·7	28·2

Molasses grass gave the highest yield while the other three species were about equal. There was a marked decline in yield during the second season, though molasses grass retained its superiority over the others.

The effect of the legumes on the mean yield of dry matter (DM) and of digestible crude protein (DCP) from the pastures is shown in Table I. The percentage of digestible crude protein was calculated from the Glover, Duthie and French equation (1) namely, digestibility coefficient = 70 log. crude protein — 15, which gives an average estimate of the apparent digestibility of the crude protein contained in animal feeds.

TABLE I.—THE EFFECT OF LEGUMES ON YIELD
(DM in cwt. per acre: DCP in lb. per acre)

MIXTURE:	Grass alone		Grass and clover		Grass, clover and lucerne		S.E. of differences	
Year	DM	DCP	DM	DCP	DM	DCP	DM	DCP
1955	48·3	299	39·3	287	34·8	302	3·2	26·7
1956	28·4	79	29·2	152	26·9	157	2·0	14

In the first season the legumes caused a highly significant depression in the dry matter yield of the pastures, but the mean yield of digestible crude protein from the grass/legume mixtures was about equal to that from the grasses in pure stand.

In the second season there was no depression in yield of dry matter due to the legumes, and the yield of digestible crude protein from the grass/legume mixtures was approximately twice that from the grass alone.

At the time of the first grazing in 1955 the average crude protein content of the swards was about 21 per cent of the dry matter. Subsequent values for this constituent were markedly less. Excluding the first values for crude protein, the mean protein content of the pastures during both seasons, expressed as a percentage of the dry matter, was:—

	Crude protein	Digestible crude protein
Grass alone	7·1	3·2
Grass plus clover ..	9·1	4·7
Grass plus clover plus lucerne	10·0	5·5

The application of superphosphate significantly raised the mean dry matter yield of the herbage from 32.5 cwt. per acre (P0) to 45.0 cwt. (P1) in 1955 and from 24.3 cwt. (P0) to 30.4 cwt. (P1) in 1956. No further advantage was gained by using the P2 level of application either during establishment or subsequently. This result confirms previous work reported by Dougall (2) who suggested that an optimum application for establishment rarely needs to exceed about 1¼ cwt. per acre of triple superphosphate.

PART II

EXPERIMENTAL

Three applications of gypsum, each of 1½ cwt. per acre, were made from 1956 to 1958. In 1957 the P1 plots were brought level with the P2 plots by an application of 1 cwt. per acre of triple superphosphate. Thus, during the four seasons a total of 4 cwt. per acre of superphosphate was given to each of these two treatments, the difference being that the phosphate was applied in a series of small dressings on the P1 plots, and in a single large dressing on the P2 plots.

RESULTS

In the absence of gypsum the pronounced decline in the mean annual dry matter yield from the pastures continued in the third and fourth seasons, falling from 40.5 cwt. in 1955, to 28.2 cwt. in 1956, and down to 16.1 and 16.7 cwt. in 1957 and 1958 respectively.

The mean annual dry matter yield per acre of each species during the four seasons was:—Molasses grass 36.4 cwt.; setaria 26.2 cwt.; Nzoia rhodes 19.8 cwt.; and star grass 19.1 cwt. The rhodes grass persisted poorly after its first two seasons of growth.

The effect of the legumes on the mean yield of dry matter and of digestible crude protein in the presence and absence of gypsum is shown in Table II.

TABLE II.—THE EFFECT OF LEGUMES ON YIELD
(DM in cwt. per acre: DCP in lb. per acre)

MIXTURE:		Grass alone		Grass and clover		Grass, clover and lucerne		S.E. of differences	
Year and Treatment		DM	DCP	DM	DCP	DM	DCP	DM	DCP
1957	Gypsum ..	16·3	54	29·9	241	33·8	269	2·0	22
	Control ..	14·1	47	17·4	80	16·9	78		
1958	Gypsum ..	15·5	54	34·6	300	37·3	291	1·8	20
	Control ..	14·1	48	17·5	85	18·3	87		

In the absence of gypsum the legumes doubled the digestible crude protein yield during the third and fourth seasons, but were relatively ineffective in raising the dry matter yield of the pastures. The application of gypsum, however, stimulated legume growth very significantly and the dry matter yield was roughly doubled, while the yield of digestible crude protein was increased four- or five-fold. The inclusion of lucerne in these mixtures failed to raise the yields significantly above those of the simple grass and clover mixtures. The influence of gypsum on grasses in pure stand was negligible.

When the clover component was subtracted from the mixed herbage it was found that the dry matter yield of grass grown in association with clover was significantly higher than the yield of grass grown in pure stand, and this is illustrated by the following data:—

	(CWT. PER ACRE)		
	Grass in pure stand	Grass grown with clover	S.E. of difference
1957	16·3	22·5	1·6
1958	15·5	24·5	2·0

It therefore appears that the substantial improvement in yield from the mixed swards which resulted from the application of gypsum was due not only to the greater bulk contributed by the clover, but also to a stimulation of the associated grasses through the clover. Some analyses that were carried out in 1957 on the grasses alone from eight related plots with and without clover, showed that their crude protein content had been significantly raised when grown with clover. The following means of crude protein content, expressed as a percentage of the dry matter, illustrate this point.

Grass in pure stand	Grass grown with clover	S.E. of difference
7·75	9·63	0·54

This suggests that the enhanced growth of the grasses may have been due to a release of nitrogen by the actively growing clover.

As may be expected, the overall quality of the herbage was greatly improved in those swards which contained vigorously growing legumes. Thus, the mean protein content of the pastures during 1957 and 1958, expressed as a percentage of the dry matter, was:—

		Crude Protein	Digestible crude protein
Grass in pure stand	Gypsum	7·3	3·3
	Control	7·4	3·4
Grass and Clover	Gypsum	11·8	7·1
	Control	9·4	5·0
Grass, Clover and Lucerne	Gypsum	11·6	6·9
	Control	9·1	4·7

It is seen from this data that grass in pure stand had the lowest average quality, while grass with non-vigorous legumes was better, and grass with vigorous legumes was the best. The figures also show that no increase in quality resulted from the addition of lucerne to the mixtures.

During 1957 and 1958 the effect of superphosphate in the absence of gypsum was negligible, but in the presence of gypsum there was a significant dry matter yield increase as shown by the following data: —

	(Cwt. per Acre)		
	P0	P1	S.E. of difference
1957	21·5	30·1	2·0
1958	21·6	34·5	1·8

This beneficial effect of superphosphate in the presence of gypsum was probably due to stimulation of the legume component by the combined phosphate and gypsum. In this trial there has been no significant difference between applying phosphate in a series of small dressings (P1) compared with supplying the same quantity in one large dressing (P2).

Summary and Discussion

Part I.—Comparisons were made between grasses in pure stand and grasses in mixture with Kenya white clover and lucerne during the first two seasons of a four-year trial, when phosphorus was the only fertilizer used. In the first season the grass/legume mixtures yielded less dry matter than grass alone, but were equal in yield of digestible crude protein. In the second season the grass/legume mixtures were equal with grass alone in their dry matter yield, but gave about double the yield of digestible crude protein. The application of triple superphosphate significantly increased the yield of dry matter: 2 cwt. per acre was as effective as 4 cwt. during the year of establishment.

Part II.—The comparisons were continued during the last two seasons, but with gypsum as an additional treatment. In the absence of gypsum the legumes failed to raise the dry matter yield of the pastures, although they raised the yield of protein. In the presence of gypsum, there was a highly significant increase in legume growth and a consequent marked superiority of yield from the mixed swards over grass in pure stand. The influence of gypsum on grasses in pure stand was negligible. The presence of fertilizer phosphorus failed to raise the dry matter yield of the pastures in the absence of gypsum, but caused a significant yield increase in the presence of gypsum.

It appears from this trial that Kenya white clover can benefit associated grasses if its growth is not retarded by soil nutrient shortages. If its nutrient requirements are adequately supplied there is a possibility that this clover may be successfully used in the Trans Nzoia, and in comparable mixed farming areas, to increase both the yield and quality of pastures.

Acknowledgement

I am very grateful to the two statisticians, Dr. J. S. F. McCulloch of the East African Agriculture and Forestry Research Organization, and Mr. R. T. Clarke of the Department of Agriculture, Kenya, for having carried out the analysis of variance on the data from this trial.

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NOTES ON ANIMAL DISEASES

XXIX—FOOT ROT AND FOOT DISEASES OF SHEEP

By Dr. H. T. Carroll, Department of Veterinary Services, Kenya

(Received for publication on 22nd October, 1960)

CONTAGIOUS FOOT ROT

Etiology

Prior to 1938 there was some confusion about the cause of Contagious Foot Rot, and it was believed that it was due to Fusiformis necrophorus. However, in that year Professor W. I. B. Beveridge demonstrated that the actual cause was the organism Fusiformis nodosus. Commonly Spirochaeta penortha was also present. It is usual to find Fusiformis necrophorus and other organisms present in the lesion as contaminants. There has been some suggestion recently that a virus might cause the condition, but this hypothesis has not been proved. Contagious Foot Rot is a disease which only affects sheep.

All breeds of sheep are susceptible, but it is believed that British breeds and their crosses have a relatively greater resistance than Merinos, although once a sheep is infected the disease is just as severe in any breed. The disease affects sheep of all ages including lambs.

Degree of Contagiousness

The organism primarily responsible for the disease does not live in the soil for longer than seven days, but for practical purposes it is generally assumed 14 days. The infective agent may survive longer in foot clippings, mud or sheep faeces, but probably never for more than three weeks. Chronically infected animals (carriers) may retain the infection for over three and a half years; in superficial skin lesions between the claws of apparently recovered sheep for as long as seven and half months; in lesions under the horn in mis-shapen hooves on apparently recovered sheep for at least one week and in recovered sheep showing no definite lesions for at least one week. It is considered that sheep entirely free of any lesions for from four weeks to four months after recovery are free of the infective agent. As a general rule Contagious Foot Rot first appears and spreads most rapidly during the green lush periods, but this is not always so.

Symptoms

The first warning sign of Foot Rot is lameness and this is, most commonly, in more than one foot of the same sheep. The percentage of sheep affected increases rapidly, and it is common to have 30 per cent of the flock, and, not unusually 90 per cent of the flock, infected. Both claws of the same foot are infected always, and again it is emphasized, generally more than one foot on the same sheep. It is common for infected mothers to spread it to suckling lambs.

The earliest lesions observed are inflammation of the skin in the cleft between the claws or in the fold of the skin between the heels. This skin shows reddening and "weeping" and later one observes the formation of a greyish necrotic material. Separation of the adjacent wall and sole from the underlying soft interior of the foot follows and, finally, the outside walls become separated, leaving the hoof attached to the foot only at the coronet. Underneath the separating horn there is greyish foul-smelling material, which is characteristic of Foot Rot. There is no discharge of pus. The lameness becomes accentuated and the affected sheep quickly loses condition. If both forefeet are affected the animal will be seen grazing on its knees, and bruising of, and denudation of hair on, the knees will be noticed. If one or both hind feet are affected the animal will be seen attempting to move on its belly. Due to lack of wear the hooves will become overgrown and mis-shapen. If not treated the disease will persist for months, but may heal spontaneously although generally the animals die from starvation or fever. In the latter case there is commonly a "break" in the wool. Sometimes, but rarely, the disease may injure ligaments, tendons and even bones.

Points to be Remembered in Diagnosis

1. Sheep of all ages affected.
2. Always both claws and generally more than one foot infected.
3. The condition spreads rapidly and up to 30 per cent or more of the flock affected.

4. The typical Foot Rot smell.
5. No pus.
6. Often a history of an outbreak after new sheep have been introduced on to a property.

Specimens for Laboratory Diagnosis

Deep scrapings and smears from the lesions taken well down after the horn has been pared away are required for Laboratory diagnosis. These should be allowed to dry thoroughly, or fixed in alcohol, and wrapped separately. Several should be sent from different sheep.

Prevention

1. Paring of the feet as frequently as necessary.
2. Careful inspection of the feet of all bought sheep, and if there are suspicious signs paring and dipping them in a suitable disinfectant before bringing the sheep on to the property, and putting them into a quarantine paddock.

Control

Treatment should be carried out when an outbreak occurs, but, when possible, eradication delayed until the dry months. Six main points are to be observed in the treatment and control of Foot Rot:—

1. Detection of all cases.
2. Isolation of all cases.
3. Spelling of all infected paddocks for at least 14 days.
4. Adequate drainage of the foot to expose all infected tissues of the feet.
5. Use of an efficient medicament on the feet.
6. Protection from infection of all clean sheep.

Before eradication is commenced one should—

Check the fences—boundary fences and isolation paddocks must be sheep-proof.

Take care in moving sheep—so that clean sheep are not travelled over contaminated ground. If it is impossible to avoid this then sheep must be walked through a portable foot bath directly into their respective paddocks.

Get equipment ready. The essentials are proper foot baths, disinfectant solution, sharp knives and secateurs and a raddle.

When Foot Rot is diagnosed the affected flock should be isolated immediately. If it is only a very small flock it is preferable to sell them for slaughter. Should this prove uneconomical start a programme of foot bathing each four to five days or twice weekly and endeavour to keep the sheep on short pasture. This will check the spread of the disease in the flock, and at this time only the worst cases need be pared and the eradication commenced at the beginning of the dry season. Remember that Foot Rot can be eradicated from a property in one season. The best way is to attack through the weak points which are:—

The organism dies in the soil in a short time.

Almost any good disinfectant rapidly kills it once the foot is thoroughly pared.

Dry weather, either hot or cold, slows its spread.

At the same time it is important to guard against the strong points of the organism. They are:—

The Foot Rot germ is highly contagious and can be carried from one sheep to another in many ways—by instruments, on foot parings, or on the contaminated soil on one's boots.

"Carrier" sheep can keep the disease alive in a flock from one season to another. In "carriers" a pocket of infection has been overgrown by healthy horn. These feet break down under damp conditions and can cause a flare-up of infection. One such sheep can be enough.

Take special care of rams. Remember that the pain and fever caused by Foot Rot can produce a temporary infertility which may last for two months *after* the disease has been cured.

The basic plan is to inspect all the sheep thoroughly, then separate off the healthy sheep and keep them on clean ground. The feet of the healthy sheep are pared and put through a foot-bath before removal to a clean paddock. They are foot-bathed weekly and re-inspected in three weeks. The infected sheep have their hooves thoroughly pared and put through a foot-bath, and then placed in a hospital paddock. They should be put through a foot-bath at least once weekly and frequently twice weekly, and at the end of three weeks the apparently cured sheep transferred to an observation paddock. The sheep in the observation paddock should be foot-bathed once weekly for three weeks and then, if cured, transferred to the clean paddock. Under Kenya conditions where many properties are not highly improved it may be necessary to transfer them directly to the paddock where the original clean sheep are depastured. The same treatment should be continued with sheep which are still infected after three weeks and it may be necessary to continue this work for up to two months. Even after this period it is possible that a few sheep may still resist all methods of control and it is preferable to slaughter these animals. Remember that after foot bathing sheep should be transferred to a paddock which has been spelled from sheep for at least two weeks.

It must be emphasized that paring is the most essential part of the operation, and for this reason bleeding is secondary to thorough paring. In some cases it is necessary to mutilate the foot in order to remove all infective material. This is specially so with "carriers" where pockets of infection can be found imprisoned under a layer of horn well up towards the coronet. However, cuts which will cause bleeding should be left till last as bleeding obscures the field of work. Paring is the operation which must be carried out perfectly and if one hoof in, say, 100 feet, is imperfectly pared it is possible that the infection can be perpetuated. Therefore, it is necessary to ensure that the operation is carried out in easy stages and every measure to facilitate such work will be worth while. Sheep cradles are now available and render much less arduous the work of attending to the feet. Where the farmer does not possess cradles the sheep can be sat against a few bags of superphosphate or grain in such a way that the body is held firmly. The secateurs and knives should also be very sharp. Long bladed secateurs are good for quick removal of the bulk of the horn. Straight blades give a better cut than curved ones on soft hooves. A curved bladed knife is the best for use for searching between the claws and for following up crevices. Instruments must be disinfected in a one-in-twenty Lysol solution after working on infected sheep. Parings should be disposed of by burying or covering with Lysol solution.

The Foot Bath

The dimensions of a foot-bath suitable for an average Kenya flock would be 20 ft. long and 8 in. to 10 in. wide. The exit opens into a draining pan in two compartments each holding about 18 sheep and floored with draining boards or concrete. A sheet of iron 14 to 18 in. high on the sides of the bath will cut down loss of fluid by splashing. A layer of straw, wool scraps or "super" bags on the floor of the bath will prevent slipping. The bath should be 6 in. deep and the disinfectant solution at least 4 in. deep to ensure that the feet and pasterns are completely immersed. The sheep should remain in the draining pen for one hour before being transferred to a clean paddock. Permanent foot baths have the advantage that they can be well constructed with concrete draining pens, but have the disadvantage that sheep must be brought from all parts of the farm to the foot bath, and where this involves walking over infected ground portable foot-baths have a definite advantage. Portable baths can be made from heavy black iron sheets 6 ft. by 3 ft. turned up at the edges to give a depth of 6 in. and welded. Heavy wire mesh reinforcement with about 2½ to 3 in. between rods is placed in the bottom of the bath to give a foothold. The shallow trays can be clipped together end to end to give any desired length of bath. Temporary cyclone fencing along the sides forms the race. The partitions at each section, over which the sheep must step, help to ensure that no affected feet are held out of the solution.

The Medicaments

Formalin is the best disinfectant to use for efficiency and safety. It is used as a 5 per cent solution of commercial Formalin in water (1 in 20) for the first foot baths if sheep are stood in it for 10 minutes or longer. A walk-through bath is sufficient for follow-up baths after the first week if the strength is increased to 1 in 10 (10 per cent). Formalin does not stain wool. It is not corrosive so can be used in portable steel baths. Sheep are unlikely to drink it, but it is unwise to put hot and thirsty sheep into a foot-bath. Formalin solutions when protected from rain tend to increase in strength due to evaporation. There may be as much as 25 per cent increase in strength after five weeks exposure in the bath. It is always advisable to note the level of the solution after foot bathing is completed so that it can be brought to the correct strength if rain falls before it is used again. Formalin baths can be used four or five times before being discarded. Organic matter does not appreciably affect Formalin solutions on standing. Nevertheless, it is wise to take some precautions to keep the bath clean. Yarding the sheep for two hours hours before foot bathing will help to reduce this contamination.

Copper sulphate is used as a 10 per cent solution (1 lb. to 1 gallon). Its disadvantages are that it stains wool, is occasionally toxic by absorption through pared feet, loses effectiveness when the bath becomes dirty, and it cannot be used in steel foot-baths.

Use of Other Drugs

The following drugs are used in hand-dressing feet. They all give a high percentage of cures. Feet must still be pared thoroughly before use. *Chloramphenicol* (e.g. Chloromycetin), as 10 per cent solution in methylated spirits, is brushed into the feet. It is expensive. *Oxytetracycline* (e.g. Terramycin) is made in the form of an ointment which is rubbed into the surface of the foot. It is less expensive. *Quaternary Ammonium* (e.g. Cetavlon) is cheaper than either of these compounds.

To save cost, the unaffected claws may be dressed with Formalin solutions (10 per cent). After treatment the sheep must be stood on concrete or battens for an hour. These treatments have a place with small flocks and stud sheep. They are also useful for some stubborn infections which do not respond to Formalin.

Once Foot Rot has been eradicated all future purchases should be foot bathed when they come on to the property even if purchased from a Foot Rot-free property.

Foot Abscess

Foot Abscess is a non-contagious infection of the foot of sheep. It is a disease that occurs wherever there is excessive rainfall, the cause being *Fusiformis necrophorus*, a common inhabitant of the soil especially where it is contaminated with sheep droppings. In this respect it differs from Foot Rot which is caused by a germ that can only survive in the feet of affected sheep and lives for less than a week in the soil. It seldom affects more than 5 per cent to 10 per cent of the flock. The infection gains entrance into the hooves through faults in the horn or abrasions to the skin. It occurs mainly in older sheep, especially among those with feet of bad conformation. There are two distinct types of Foot Abscess. In the first type the infection enters the foot in the region of the toe and in the second type it enters through the skin in the region of the heels.

The following is a general description of the first type by Dr. Gregory, who discovered the difference between Foot Abscess and Foot Rot in 1934:—

> "In the majority of cases the earliest sign of infection is an acute lameness which is often made evident by an animal 'carrying' one leg. Examination may fail to reveal any obvious lesions, but generally one claw is found to be hot and pressure applied to the wall causes the animal to flinch. Careful paring away of the horn at the sole in the region of the incurved portion of the wall on the inner border or sometimes up along the anterior (front) aspect of the claw will reveal the presence of imprisoned pus. This is generally creamy in colour and rather thick. In slightly older cases the pus may have extended posteriorly (to the rear) under the sole, or it may have 'broken out' at the coronet, most commonly on the anterior aspect of the claw, but often half-way along the inner aspect in the inter-digital cleft."

The second type of Foot Abscess which commences in the region of the heels is probably due to the bad conformation of the feet leading to rubbing together of the heels. In these cases the lesions formed are near the site where the early lesions of Foot Rot appear, which calls for careful differentiation of diagnosis between the two complaints.

In the case of Foot Abscess there is marked inflammation at the site of the infection with the formation of proud flesh which bleeds easily on contact. There is, however, no separation of the horn. Pus rapidly forms involving the ligaments and tendons in close proximity and causing swelling of the tissues of the outer aspect of the foot above the coronet. The pus may burst out of this point and can be squeezed out by the original opening between the heels. Secondary infection frequently occurs at this stage leading to the spread of the infection to the joints and tendons as far up the leg as the fetlock or higher. A point of considerable importance is that the majority of cases of Foot Abscess are confined to one claw and usually to one foot.

In general, the condition of Foot Abscess is more acute and appears to be more painful than contagious Foot Rot. Lesions may continue to discharge pus for some weeks or months, but may clear up.

Specimens for Laboratory Diagnosis

Pus smears from an affected foot in the early stages of the disease are required.

Treatment

The first essential is to provide for drainage of the pus and to that end proper paring of the foot is necessary. When dealing with the first type of Foot Abscess one can often notice a dark line running from the point of the toe to the abscess above the coronet. If the point of the toe is removed with secateurs creamy pus will ooze out and thus drainage will be effected. If the abscess has not burst or there is no drainage it should be lanced. Generally, foot bathing is of little value in the treatment of Foot Abscess. The use of penicillin or sulphamezathine as an injection has been successful in very early cases, but is of no value in the older more chronic ones. The routine paring of feet will do much to prevent the incidence of this condition, but Foot Abscess cannot be eradicated.

FOOT SCALD

Foot Scald is a condition of unknown cause in which the skin between the claws is red and swollen and the foot is hot. The affected sheep suffer acute lameness which is generally present on all four feet. A very high proportion of the flock is affected at the one time. "Scald" occurs mainly on soft moist country in seasons of excessive rainfall, and it is believed that the lameness is due to a softening of the horn and hoof, particularly between the claws, with subsequent injury due to pasture dragging between the claws. It is also thought that a worm parasite (Strongyloides), which is present in large numbers in wet soil contaminated by sheep droppings, may cause or accentuate the condition when they penetrate the skin of the foot.

"Scald" simulates the early stages of contagious Foot Rot in that, in advanced cases, the sole may become under-run. Therefore, much care must be taken in differentiation. It has been suggested that "scald" is a predisposing cause of contagious Foot Rot. However, "scald" does not have the typical Foot Rot smell (in fact, there may be a suggestion of an odour of ammonia) and it is not contagious.

Treatment

As "scald" is probably caused by moist conditions which soften the feet it is logical that affected sheep should be put through a formalin bath to harden the feet and, perhaps, kill any early infection. Constant attention to the feet and the passing of sheep through formalin baths will help to prevent the onset of this condition.

Contagious Pustular Dermatitis

(See Notes on Animal Diseases IX.)

DIFFERENTIATION DIAGNOSIS

FOOT ROT	FOOT ABSCESS	FOOT SCALD
1. *Actual Cause—*		
Fusiformis nodosus; a contagious disease.	Non-specific organisms, the most common Fusiformis necrophorus: a non-contagious disease.	No known bacterial cause. A non-contagious condition.
2. *Predisposing Cause—*		
Moist wet conditions.	Injury to foot, expecially grass seeds or malformed feet. Generally very wet conditions.	"Soft" country under very wet conditions.
3. *Types affected—*		
All breeds and ages including lambs.	All breeds, but generally older sheep. Lambs seldom affected.	All breeds and ages including lambs.
4. *Diagnosis and Symptoms—*		
Up to 30% and commonly 90% of flock affected.	Seldom more than 5% to 10% of flock affected.	Up to 90% of flock affected.

Contagious Pustular Dermatitis—(*Contd.*)

DIFFERENTIATION DIAGNOSIS—(*Contd.*)

FOOT ROT	FOOT ABSCESS	FOOT SCALD
Always both claws and generally more than one foot affected.	Generally only one claw of one foot affected.	Generally the four feet affected.
Seldom if ever any pus present.	Always pus present.	Seldom any pus present except in the later stages with secondary infection.
The typical Foot Rot smell.	The usual smell of pus.	A smell due to maceration of the tissues often with a suggestion of ammonia.
Very rapid spread under wet conditions.	No true spread. Is a sporadic condition.	The condition appears in the flock at the one time.
Only the hoof is affected.	Leg above hoof may be swollen.	Generally only hoof affected.
Early signs in the cleft of the foot, or the heels.	Starts in the toe usually except heel abscesses.	A superficial condition but later may be under-running of the wall simulating Foot Rot.
Excessive loss of condition of sheep.	Loss of condition is not as rapid.	Sheep may lose condition but recover rapidly after foot bathing.
Eradication— Can be eliminated.	Cannot be eliminated.	Can be cured quickly by hardening the feet with formalin solutions.

BREEDING BEHAVIOUR OF CENCHRUS CILIARIS IN KENYA

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(*Received for publication on 5th December, 1960*)

Since the opening of the Grassland Research Station at Kitale in 1950 numerous varieties of *Cenchrus ciliaris* (African foxtail or buffel grass) have been collected and the best forms selected with a view to developing strains suitable for cultivation in semi-arid areas, a work which requires some knowledge of the breeding behaviour. As no information on the breeding behaviour of *Cenchrus ciliaris* was found in the literature a series of progeny tests was undertaken in 1955. This work was already in progress when Snyder *et al.* [1] described *Cenchrus ciliaris* (under the name *Pennisetum ciliare*) as an apomict. It was decided, however, to continue our study in order to find out whether the local varieties breed in the same way as those investigated by Snyder *et al.*

Six morphologically distinct varieties were selected for the progeny tests:—

*K 5146 *Kabete Selection, Kenya.*—A very low, prostrate type with numerous basal leaves. The leaves are soft, arching, somewhat dull green in colour, with the sheaths and the upper surface of blades covered with numerous short hairs.

K 5148 *Kabete Selection, Kenya.*—An erect, very tall type with leaves high on the stem. The leaves are long and broad, soft, arching, somewhat dull green in colour, and glabrous except for a few hairs at the bases of leaf-blades.

K 5363 *Chipinga Variety from Rhodesia.*—An erect, tall rhizomatous type, with leaves high on the stems. The leaves are fairly long, arching, tough, bluish-green in colour, and glabrous except for a few hairs at the base of blades.

K 53125 *from Mpwapwa, Tanganyika.*—A semi-erect type, with leaves rather high on the stems. The leaves are long, narrow, straight and glabrous except for long scattered hairs on the upper surface of the blades.

K 52528 *from West Suk, Kenya.*—An erect, fairly tall type with leaves high on the stems. The leaves are rather short, slightly arching, bright green in colour, and glabrous except for long scattered hairs on the upper surface of the blades.

K 53734 *from Meru, Kenya.*—A semi-erect, low type with numerous basal leaves. The leaves are arching, soft, somewhat dull green in colour, with numerous long hairs on the sheaths and the upper surface of the blades, and some scattered hairs on the lower surface of the blades.

These six varieties also differed in spikes, spikelets and susceptibility to disease, and were easily recognizable.

In 1955 one tuft of each variety was split and the splits planted in adjacent rows to facilitate cross fertilization if this should occur naturally. To avoid incompatibility because of differences in the time of flowering, seeds were collected only from those panicles which had flowered simultaneously with the other varieties and this precaution was observed for each generation. Seed from each row was planted in boxes in 1956, and 70 seedlings of each variety were transplanted to adjacent plots at a uniform spacing. This same process was repeated in 1957 and in 1958, when 105 plants of each variety were grown. A total of 245 plants of each variety was thus examined during three generations. In all three generations the plants of each of the six varieties were invariably uniform and true to type. This shows that our varieties do not mix even if grown closely together. They breed in the same way as those investigated by Snyder *et al.* and should be considered as apomicts.

[1] Snyder, L. A., Hernandez, A. R., and Warmke, H. E. (1955). The mechanism of apomixis in *Pennisetum ciliare*. *Bot. Gaz. 116*, 209.

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*The K figures denote the introduction numbers of the Kitale Grassland Research Station.

ESTABLISHMENT OF CENCHRUS CILIARIS FROM CARYOPSES

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(*Received for publication on 22nd December, 1960*)

A major disadvantage of *Cenchrus ciliaris,* which is one of the most important grasses at Kongwa, is the liability to infection with ergot (*Claviceps* spp.). This fungus reduced germination capacity of seeds which were harvested during a rainy season at the Pasture Research Station, Kongwa, from 65 per cent to 8 per cent. Due to Claviceps, the harvest in a rainy season had to be abandoned, and fields of *C. ciliaris* were grazed continuously till the last month of the wet season. It has been noticed that plants infected with Claviceps were avoided by cattle, probably due to the characteristic smell of the sticky fluid which occurs at the conidial stage (*Sphacelia segetum*) of the fungus. Ungrazed plants were trampled, which might have a significant effect on carrying capacity.

The separation of healthy seed from seed infected with Claviceps in bulk seed production is impossible, but it can be done with caryopses. Hence the possibility of the establishment of *C. ciliaris* from caryopses could have a great effect on pasture improvement by avoiding the contamination of new areas by infected seed.

Caryopses also are easier to plant with machines than are ordinary seeds of *C. ciliaris.* Caryopses are easy to store and to transport as they occupy much less space than normal seed of this grass. At this Station caryopses were obtained by hulling seeds of *C. ciliaris* by means of a home-made huller. Seeds after hulling were cleaned with a winnowing machine. From 100 lb. of seeds (five bags of standard size) 26 lb. or about one-quarter of a bag of caryopses were obtained. This figure varied accordingly to the quality of the material used for hulling. Hulling did not damage caryopses and their germination capacity in a seed incubator was very good. In U.S.A. caryopses are sown at the rate of $\frac{1}{4}$ to $\frac{1}{2}$ lb. per acre and the same rates are used in Queensland [3].

After an observation plot sown in 1956 experiments were carried out in the two sucessive rainy seasons, 1958 and 1959, to investigate the possibility of growing *C. ciliaris* from caryopses. In both seasons the experimental designs were the same, four randomized blocks of three plots each. Treatments also were repeated namely treatment (A) Caryopses, (B) Seed picked by hand, and (C) Seed taken at random. Each plot was 3 ft. square. Four rows of 25 seed each were planted per plot. Seed was planted at a depth of $\frac{1}{4}$-in. All plots were seeded by the same person.

Seed used was 15 months old and had a high germination capacity. The seed was harvested by hand when the caryopses were completely ripe. The caryopses had been obtained by hand cleaning.

Soil temperature was recorded at the depths of $\frac{1}{2}$ in. and 2 in. For this purpose two mercury-in-steel thermographs were used. The bulbs were horizontally placed at above mentioned depths. Meteorological data had been recorded at the Meteorological Station 0.7 miles from the experiment. The first experiment was laid down on 31st January, 1958, and the second on 3rd January, 1959. Both experiments were established when *C. ciliaris* was sown on a commercial scale at the Pasture Research Station, with seed production of between 8,000 and 10,000 lb. per year.

Meteorological and soil temperature data shown in Table 1 illustrate the conditions under which these experiments were conducted.

ENVIRONMENT

The Pasture Research Station, Kongwa, is situated in Central Tanganyika 6° 05′ South and 36° 25′ East, at an altitude of 3,350 ft.

Seasonal rainfall varied from 13 to 32 in. with an average for the last 12 seasons (1947-1959) of 21 in. The number of rainy days varied from 32 to 75 per season. Average yearly temperatures are 86° F. maximum, and 52° F. minimum.

The pastures [1] are mainly annuals with some *Cynodon dactylon, Chloris virgata* and *Cenchrus ciliaris* and the soil moisture conditions in the red sandy loam have been measured [3].

RESULTS

Emergent plants were recorded every 10 days for a month after sowing. The results are summarized in Table 2. In both experiments, plots seeded with seed picked by hand or with seed taken at random had significantly higher numbers of emerged plants than plots seeded with caryopses.

While normal seed of *C. ciliaris* germinated well in the field and under laboratory conditions, caryopses, which gave a higher percentage of germination in the laboratory than commercial seed, gave quite different results when sown in the field.

DISCUSSION

Experiments were carried out in two successive rainy seasons which were the best for the last 12 years, and if in these conditions caryopses could not achieve good results it means that there is no chance of obtaining satisfactory results under more adverse conditions.

Caryopses account for 25 to 30 per cent of the weight of normal seed. They hold a smaller amount of water on their surface than normal seed. Caryopses after saturation with water, dried during five hours on a laboratory bench, while normal seed required 24 hours for drying out.

Caryopses react to water very fast and usually they germinate sooner than normal seed, but they require more constant moisture than normal seed. As they have lost their natural protection they are more sensitive to moisture and drought and this has an adverse influence on the process of germination. This effect is more severe when changes of soil temperature are great. Caryopses placed near the soil surface are exposed to the drastic changes of moisture and temperature in the upper layer of the soil. They are unable to withstand these changes to such an extent as normal seed and this may be the main reason why it is too risky to apply this method of establishment of *C. ciliaris* with caryopses.

SUMMARY

Cenchrus ciliaris L., one of the most valuable grasses for the semi-arid parts of Africa and many parts of the world, has been cultivated at the Pasture Research Station, Kongwa, Central Tanganyika, on the commercial scale and seed production amounts to 8,000-10,000 lb. per year.

A major disadvantage of this grass at Kongwa has been its liability to severe attack by ergot (*Claviceps* spp.). In order to avoid contamination of seed, the hulls were removed and the caryopses were planted. Trials in three successive seasons showed, however, that although germination was high, survival rates were poor.

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TABLE 1(*a*).—METEOROLOGICAL DATA FOR FEBRUARY, 1958, AND JANUARY, 1959, MEAN

	RAINFALL		TEMPERATURE °F		HUMIDITY PER CENT		Sunshine Hours	Water evaporation Ins.*
	Ins.	Days	Max.	Min.	9 a.m.	3 p.m.		
February, 1958 . .	9·51	14	85	64	94	60	6·3	4·47
January, 1959 . .	5·66	9	88	64	82	48	8·0	6·11

*Water evaporation from sunken air-insulated evaporation pan, 4 ft. in diameter.

TABLE 1(*b*).—MEAN SOIL TEMPERATURE FOR FIRST 10 DAYS AFTER PLANTING

	Depth Ins.	Temperature °F at:			
		6. a.m.	9 a.m.	3. pm.	9 p.m.
1st to 10th February, 1958	½ 2	64 71	75 73	97 93	73 78
3rd to 12th January, 1959	½ 2	63 69	76 72	107 75	77 80

TABLE 2.—SUMMARY OF RESULTS

	Treatment			Standard Error	Significant Difference
	A Caryopses	B Hand picked seed	C Seed Selected at Random		
1958— Number emerged per plot	14	91	57	2·59	B > A, C at P = ·001
1959— Number emerged per plot	18	86	40	5·22	B > A, C at P = ·001

INTERNATIONAL VETERINARY ACTIVITIES

By Sir Thomas Dalling, Consultant of the Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

The nutrition of the rapidly increasing human population throughout the world causes much concern and assistance is being given in several directions by international organizations to increase the production of food for human consumption. The Food and Agriculture Organization of the United Nations, a member of the United Nations group of specialized agencies, was set up in October, 1944, and is one of these organizations. Beginning with 42 member countries, the number has now increased to 76. The aims of F.A.O. are: (1) to help nations to raise the standard of living; (2) to improve nutrition of the people of all countries; (3) to increase the efficiency of farming, forestry and fisheries; (4) to better the conditions of rural people; (5) through all means to widen the opportunity of all people for productive work.

The importance of livestock in all countries is appreciated by the Organization and animal production receives much attention. Improvement in livestock production is urgently required to increase the availability of the much needed proteins of animal origin and of animal by-products. In addition, animals are still required in some regions for use for agricultural and transport purposes and their value in soil fertilization will probably continue. Improvement of animal health and control of animal diseases are recognized as vital factors in increasing animal production and efforts are being directed towards these ends. Although more livestock is necessary, it follows that the better the health of animals, the greater will be the production from smaller numbers of animals; a smaller total area of land will be required to produce food for these smaller numbers and so, eventually, more land could be available to raise crops to feed the human population. Improvement of animal health and control and eradication of animal diseases constitutes a world-wide challenge which requires the active collaboration of all countries.

Most attention is, of course, being given to countries classified as under- or less-developed, because the potentialities in some of them to increase animal production is great. Concurrently with work on improvement in animal health and disease control, production of more and better feeding stuffs for animal consumption, improvement of pastures, improvement in some aspects of animal husbandry and improvement in breeds to meet their required purposes all receive attention. It is with animal health and diseases that most veterinary technical assistance is concerned.

Veterinary technical assistance is given in several ways. At the headquarters of the Organization in Rome there is a team of veterinarians, drawn from different countries, part of whose duty is to provide information and advice on veterinary subjects to any member country, on request. The requested information may already be available in F.A.O. or it may be necessary to consult literature, reports, etc., or even to get into touch with veterinary and other authorities in different parts of the world. It is not uncommon to put veterinarians in personal touch with such authorities in other countries. There is an extensive library in F.A.O. Headquarters, in which textbooks, journals and reports are available to the staff and they are freely made use of in supplying information, opinions and advice to member countries. The headquarters veterinarians are largely responsible for the veterinary field work carried out by F.A.O.: they are in regular communication with the veterinarians assigned to member countries and supervize and advise them on their work. They visit member countries periodically to discuss programmes with the responsible authorities, to give any necessary advice on veterinary topics and to take part in meetings on veterinary and other subjects of a local, regional or world-wide character. World-wide types of meetings are also held, from time to time, at headquarters, for which the necessary arrangements are in the hands of the veterinary staff. They also participate in meetings convened, separately or jointly with F.A.O., by other international organizations which have veterinary interests. Veterinarians from headquarters are sometimes called upon to be members of teams which visit countries or regions to carry out surveys on any particular subject concerning agricultural and allied projects. From the Animal Health Branch of the Organization information, collected from many sources, is supplied for publication and the Branch itself publishes articles of general interest. An example of such a publication is the Annual Yearbook on Animal Health which contains full particulars, in tabular form, of the incidence of animal diseases in countries throughout the world with particulars of the methods adopted for their control and a series of articles on topical subjects, some prepared in Rome and some by well-known veterinarians in various parts of the world.

Technical assistance to individual member countries is given in several ways. Following discussions in the country and in Rome, requests are made by the countries for technical assistance in specific subjects. The requests are placed in order of priority and are carried out according to the availability of the funds and the possibility of making detailed arrangements. Normally, one or more veterinarians, appointed by F.A.O., are assigned to the requesting country to proceed with the work. These veterinarians drawn from many parts of the world are usually experienced in the type of work required and have often had service in countries with climatic and other conditions similar to those of the country in question. Young veterinarians, specially qualified and experienced in some special veterinary subject may also be appointed, especially for work which does not demand experience of a special climatic condition.

A veterinarian assigned to a country works as an adviser, assisting and collaborating in planning and operating schemes for animal health improvement and disease control and in giving instruction to national veterinarians and others on techniques for the diagnosis, prevention and control of disease.

For the satisfactory control of some animal diseases in a country and for preventing the introduction of disease, legislative action is necessary and regulations have to be formulated: F.A.O. veterinarians give advice on this subject and often assist in drawing up the regulations.

Some of the veterinarians spend much of their time in the laboratories in the countries to which they are assigned, teaching and supervising the preparation of biological products for use in animal disease control schemes. Others are concerned with the veterinary schools in the country and advise on and assist in the introduction of changes which are considered beneficial. Activities in slaughterhouses come under the purview of some of the assigned veterinarians. They advise on the construction and establishment of new slaughterhouses and alterations in existing premises to meet more modern requirements, plan operations and supervision of staff, advise on and give instruction in meat inspection, refrigeration techniques and safe disposal of waste and condemned material as well as on the care and inspection of animals destined for slaughter during their transport to and after collection at the slaughterhouse.

Veterinarians work sometimes in more than one country in a region, devising schemes which may benefit the whole region by preventing spread of infections from country to country. One of the conditions imposed by F.A.O. on member countries receiving such technical assistance is that one or more national veterinarians are attached to the F.A.O veterinarian so that the work may be continued satisfactorily and without a break after his departure.

For the diagnosis of and control of many of the infectious diseases biological products are required. For various reasons including economy, the required materials are being produced in the different countries, where these products have been prepared in the past. More modern techniques are now in use and result in more efficient products. Special equipment is required and F.A.O. has supplied a considerable amount to a number of member countries. In the control of other diseases, drugs not available in a country of region are sometimes necessary, for example, for the control of parasitic diseases such as liver fluke disease and diseases caused by worms in the stomach and intestine of sheep and cattle. F.A.O. has supplied considerable quantities of the necessary drugs in order that extensive control schemes could be successfully inaugurated. Similarly, the control of diseases caused by external parasites, for example, sheep scab, has been encouraged by the provision of a quantity of the necessary medicaments for use in the form of dips and sprays.

F.A.O. provides assistance for training in modern scientific methods. This is done as much as possible by F.A.O. veterinarians during their assignments to a country. In addition, however, fellowships are awarded by F.A.O. to selected national veterinary personnel, enabling them to proceed to another country to receive special tuition and experience in a specific subject, a group of subjects, or in the more general aspects of animal health and disease control. Such trained national personnel, on return to their country at the completion of their training, are expected to be employed in the type of work in which they gained experience abroad, to meet the requirements in their country.

While fellowships are allotted mostly for individual travel and training, F.A.O. also convenes and operates training centres for veterinarians from countries often in a region. The courses vary from more general instruction for two-three weeks on such subjects as the preparation and testing of virus-vaccines, to more detailed work for several months on subjects such as milk and meat hygiene and infertility in animals. For the courses of longer duration, the host country sometimes provides part of the necessary financial outlay.

In order to obtain up-to-date information on specific subjects and to bring together recognized world authorities on them, F.A.O. has set up panels whose members, conversant with essential parts of the subject, meet from time to time and, together with F.A.O., prepare reports for general distribution. Examples are those dealing with infertility in animals and with tick-borne diseases. F.A.O. also links up with other international organizations in the formation and work of such panels, for example, brucellosis, created jointly by F.A.O. and the World Health Organization (W.H.O.), the subject being of much importance in both human and veterinary medicine.

For discussions of problems of animal health and control of animal diseases which affect the economy of a number of countries in a region and to draw the attention of governments to the steps which can be taken to improve the position, meetings, attended by representatives of the countries, are convened in the region. Sometimes such meetings are arranged jointly by F.A.O. and another international organization—the International Office of Epizootics (O.I.E.), which has been in existence since 1927 and whose headquarters is in Paris. The reports from such meetings, agreed by all present, are circulated to governments of all F.A.O. member countries and are made available for distribution.

F.A.O. collaborates with other international organizations interested in veterinary problems in different parts of the world. The International Office of Epizootics, mentioned above, is an independent organization whose work is confined entirely to veterinary matters and whose finances are provided by its 63 member countries. In addition to convening regional meetings on veterinary problems, often jointly with F.A.O., an annual meeting is held in Paris when delegates from member countries and observers from many parts of the world attend. In addition to receiving reports of the animal disease from member countries, papers are given and discussions take place on some of the most recent research work on animal disease problems. Representatives of F.A.O. participate fully at these annual meetings.

The O.I.E. also collects and disseminates information on outbreaks of diseases: information is sent to interested countries whenever received, and to all other countries at short regular intervals. O.I.E. also publishes an interesting journal bi-monthly. Research work is encouraged and is sometimes financed by O.I.E. A close association exists between F.A.O. and O.I.E.

The World Health Organization whose headquarters are in Geneva, is interested also in veterinary work, particularly in animal diseases which may have a bearing on human health. Meetings are held from time to time when full consideration is given to the most recent available information on diseases affecting both animals and man. These are attended by experts, both medical and veterinary, in the specific subjects and the meetings form a common ground for exchange of information, following which reliable and up-to-date reports are published. Most of these meetings are arranged jointly by W.H.O. and F.A.O. Milk and meat hygienes are also dealt with by W.H.O. in collaboration with F.A.O. This collaboration is extremely valuable to both medical and veterinary services.

The Organization for European Economic Co-operation (O.E.E.C.) with its headquarters in Paris has also shown considerable interest in veterinary matters. At one time it had a Working Party on Animal Health, whose chairman was a member of the F.A.O. staff. In addition to issuing valuable publications and producing films on some of the diseases of economic importance in Europe, it arranged meetings of veterinary representatives from European countries when the problems of animal health were discussed. F.A.O. participated fully in these meetings. Although the Working Party on Animal Health has been disbanded, the O.E.E.C. is still much interested in veterinary activities and, undoubtedly, would again give serious consideration to calling together representatives of European countries to discuss any vital problems of animal disease which might arise.

Then, there is the International Veterinary Congresses with headquarters in Utrecht, Holland. It has world-wide country membership and a meeting is held once every four years when delegations from many countries meet and many important papers are presented and discussions on them take place. This body is supported financially by small contributions from veterinarians in the member countries. F.A.O. is represented on the governing body and a member of the F.A.O. veterinary staff is a member of some of the committees.

F.A.O. also collaborates wherever and whenever possible with organizations in the United States of America which are carrying out much good work on veterinary matters in many of the less-developed countries throughout the world: and with the Organismo Internacional Regional de Sanidad Agropecuaria (O.I.R.S.A.) which works in Central America, to whose headquarters a veterinarian, appointed by F.A.O., is attached.

Although F.A.O. is not empowered, generally, to engage in research, the need for such work is fully appreciated and encouragement is given whenever possible. There are a few special fellowships, recently provided, for award, under certain conditions, for research purposes: some have already been awarded to veterinarians who are working abroad.

To complete this article a few examples of the field work of F.A.O. veterinarians may be of interest.

Rinderpest or cattle plague is one of the diseases of cattle and buffalo most dreaded in parts of Africa and the Far East. In some countries, it is always present although in a "silent" or somewhat quiescent state: on occasion, however, the infecting virus attains a high degree of virulence and the disease sweeps over districts and countries, sometimes invading several countries and causing a high death rate. In some parts of the world the disease is the cause of severe economic loss not only in animal production but also in general agriculture because at critical times there may remain no or only a few cattle or buffaloes for use in agricultural activities. From the results of research work, vaccines, the systematic use of which will prevent spread of arians have worked in some of the infected countries, teaching the national personnel how the infection, are available. F.A.O. veterin- to prepare the vaccines and advising on extensive schemes for the control of the disease; training centres have been held where the preparation of the vaccines and their testing for efficiency have been demonstrated to groups of future workers; equipment for the preparation of the vaccines has been supplied; fellowships have been awarded to enable national personnel to receive instruction in the working and maintenance of the equipment. All this assistance has led to the application of control measures which are resulting in lowering the incidence of rinderpest and has already been responsible for the clearing of some large areas. With a continuation of concentrated effort by the countries concerned and full collaboration between infected countries in a region, the progress should continue until rinderpest is no longer a menace to livestock production and to the economy of countries.

F.A.O. takes much interest in veterinary education, realizing fully that sound veterinary education is an essential requirement for an efficient veterinary service. F.A.O. veterinarians have visited many countries for information on veterinary schools and educational systems: regional meetings have been held when the only subject of discussion has been veterinary education to meet the requirements of the region: an F.A.O. veterinarian spent some considerable time in Calcutta, India, and, following his advice many alterations were made in the veterinary college there and in teaching veterinary students: F.A.O. has now arranged a world-wide meeting on veterinary education to be held in London in April, 1960, when it is hoped to discuss the subject in general terms and to make recommendations.

Foot-and-mouth disease continues to influence animal production in some parts of the world and to impede export and import of livestock and products of animal origin. Countries, free from the disease, impose severe restrictions which prevent or minimize the risks of introducing the infection. F.A.O. is much concerned with the general position; F.A.O. veterinarians advise countries on methods of control and eradication and on legislative measures to protect countries against invasion; world-wide meetings have been held for discussions on the conditions which might be imposed for safeguarding countries against the introduction of the disease; the European

Commission for the Control of Foot-and-mouth Disease was set up, at the request of governments, as a unit of F.A.O. with its own budget and is engaged in assisting European member countries in the application of measures to eradicate the disease from the country and from the whole of Europe; F.A.O. keeps in close touch with research workers on all aspects of the disease and makes recent information available.

Haemorrhagic septicaemia in cattle and baffaloes causes much economic loss, especially in eastern parts of the world. Having learned of some important work on the causal organism which might lead to the development of better vaccines for the control of the disease, F.A.O. appointed a veterinarian, familiar with this work, to make further observations on the subject and to prepare and test out the value of the vaccines under consideration. All the field work was carried out in the Far East and vaccines are still being tested on an extensive scale; the available information indicates that this newer type of vaccine is an improvement on those formerly used.

Contagious bovine pleuropneumonia is an important disease of cattle in parts of Africa, India, Australia and some few areas in Europe. Research is being pursued in different countries on improvements in the vaccines now in use for its control. F.A.O. convened a meeting of the veterinarians interested in this subject and formed a panel composed of research workers who will meet from time to time when they will compare and discuss the results of their work and provide up-to-date information for distribution.

Brucellosis in goats and sheep continues to cause much economic loss and much human disease in some parts of the world. F.A.O., with the collaboration of W.H.O., provided some assistance for the study of suitable vaccines for the protection of goats and sheep and consequent reduction in the risk of human infections. This assistance was continued for several years and has been of much value in the development of at least two types of vaccines, both of which have given promising results in small observations and will now be tested in the field on a large scale.

The serious effects of parasitic infestations of animals on animal production are well recognized, not only because of the death rate but also because of the losses from interrupted and slow development. Different types of parasites assume higher importance in different areas. Important diseases are caused by the protozoan group of parasites which are "tick-borne". Realizing their importance, F.A.O. convened a meeting attended by observers from many countries and an up-to-date report was produced for distribution. Because of the complexity and extent of the subject and the amount of research and investigation work in progress, F.A.O. has set up a panel of workers on the subject: one meeting has been held and a report from it is available. Other types of parasites have not been forgotten and F.A.O. veterinarians have investigated and given advice on the control of parasites causing such diseases as liver fluke disease, parasitic gastro-enteritis and others in several widely separated parts of the world. In some South American countries, theoretical and practical instruction has been given on several occasions to groups of veterinarians and others.

The introduction of artificial insemination as a method of breeding has attracted the attention of those interested in livestock improvement in practically all countries and there has been much demand for technical assistance from F.A.O. for instruction of the method. F.A.O. veterinarians have spent long periods in some countries demonstrating techniques and advising on and assisting in the introduction of schemes; veterinary personnel have been sent abroad to study methods in other countries. Sexual hygiene and infertility control have always been taught and dealt with side by side with artificial insemination and three training centres have been held in Sweden, each of some ten months' duration, when very thorough training in all these subjects has been given to groups of selected veterinarians, mostly from Near East and Far East countries. F.A.O. also organized a meeting at which recommendations were made on the conditions for the export and import of semen.

These are examples of some of the work carried out by F.A.O. on more specific subjects of animal health and disease control. In addition much work of a more general nature is undertaken under the technical assistance programmes when surveys of disease are made and advice given on the more general aspects of disease control and the improvements of animal husbandry and nutrition, including necessary changes, all with the object of improving and increasing livestock production.

REVIEWS

A HISTORY OF THE NATIONAL INVESTIGATION INTO THE ECONOMICS OF MILK PRODUCTION (1934-1957), by Phyllis Manning, published by the Agricultural Economics Research Institute, Oxford, 1960, pp. 83. Price Sh. 12/50.

This slim volume is a history of the investigation of milk costs in England and Wales during the period 1934-1957; a period of fundamental change in the structure of the milk industry.

As almost all facets of the milk industry of England and Wales are different from those of the industry in East Africa, this book is not likely to be of major interest to anyone interested in the local study of farm economics.

An exception must be made however of the chapter on sampling methods, and the details of the methods of costing are of interest to any economist.

W.J.A.P.

REPORT OF THE SEVENTH COMMONWEALTH ENTOMOLOGICAL CONFERENCE, 6-15TH JULY, 1960, published by the Commonwealth Institute of Entomology, London, December, 1960, pp. 399. *Price* 50*s*.

This report, which is essentially a review of progress in economic entomology in the Commonwealth during the past six years is considerably larger and perhaps more impressive than its predecessor of 1954. It is tempting to conclude from this that entomological work in the Commonwealth has likewise increased in extent and significance in recent years. This, indeed, is the impression given in Appendix V where the work of forty-seven Commonwealth organizations is reviewed at some length, and by the Proceedings of the Open Meetings (App. IV) where 31 papers are presented on the following subjects.

Recent Developments in Insecticide for Crop Protection.

Problems in the Use of Insecticides.

Hazards and Precautions Associated with the use of Pesticides.

Research on Stored-Products Pests and their control.

Biological Control of Insects and Weeds.

Insect Attack in Relation to the Physical Characters and Physiological State of the Plant.

Recent Investigations on Timber-boring Beetles.

Termite Control in Afforestation Projects and Constructional Timbers.

The Utilization of Pathogenic Organisms in the Control of Insect Pests.

Recent Advances and Current Trends in the Study and Control of Tsetse Flies and Trypanosomiasis.

Developments in the Study of the Dispersal of Insects.

Recent Research on Locusts and their Control.

One of the most interesting parts of the report is that dealing with the Commonwealth Institutes of Entomology and Biological Control. The report on the former is a clear and precise statement of the invaluable services rendered by the C.I.E. to Commonwealth entomologists and it is interesting to note that of the 54,669 insects indentified by the Institute in 1954/60, over one-third came from Africa. It is gratifying to see that all arrears in naming insects have been overtaken and that the Institute is now better equipped to deal expeditiously with collections than ever before.

The Commonwealth Institute of Biological Control has also increased its facilities and its range of activities. Two new substations have been established, one in India and one in Pakistan. Notable successes in biological control have been achieved in New Zealand, Nevis, Seychelles and Portuguese West Africa.

The Conclusions and Resolutions of the Commonwealth Conference although occupying only two pages in the Report, could if implemented have far-reaching and highly beneficial results. The following recommendations for the next quinquinnium are particularly notable:—

(1) Three additional members should be recruited to the abstracting and editorial staff of the Review of Applied Entomology.

(2) Two additional taxonomic specialists, one to work on parasitic Hymenoptera and the other on Diptera, should be recruited to the C.I.E. identification service.

(3) A substation of the Commonwealth Institute of Biological Control with a staff of two entomologists should be established in East Africa.

T.J.

ACKNOWLEDGEMENT

The photograph illustrating the recent article in this journal (*26,* 103) by Peat and Brown was taken by M. H. Arnold.

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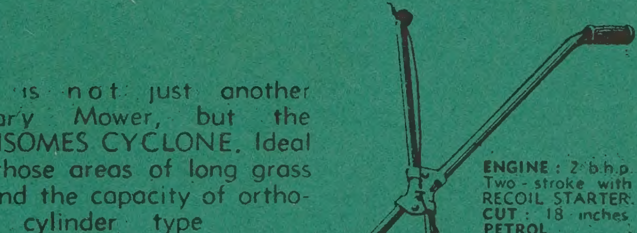

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